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THE CHROMOSPHERE AND SOLAR PROMINENCES.

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WHAT we see of the sun under ordinary circumstances is but a fraction of his total bulk. While by far the greater portion of the solar mass is included within the photosphere, the blazing cloud-layer which seems to form the sun's true surface, and is the principal source of his light and heat, yet the larger portion of his volume lies without, and constitutes an atmosphere whose diameter is at least double, and its bulk therefore sevenfold that of the central globe.

Atmosphere, however, is hardly the proper term; for this outer envelope, though gaseous in the main, is not spherical, but has an outline exceedingly irregular and variable. It seems to be made up not of overlying strata of different density, but rather of flames, beams, and streamers, as transient and unstable as those of our own aurora borealis. It is divided into two portions, separated by a boundary as definite, though not so regular, as that which parts them both from the photosphere. The outer and far more extensive portion, which in texture and rarity seems to resemble the tails of comets, and may almost, without exaggeration, be likened to "the stuff that dreams are made of," is known as the "coronal atmosphere," since to it is chiefly due the "corona" or glory which surrounds the darkened sun during an eclipse, and constitutes the most impressive feature of the occasion.

At its base, and in contact with the photosphere, is what resembles a sheet of scarlet fire. The appearance, which probably indicates a fact, is as if countless jets of heated gas were issuing through vents and spiracles over the whole surface, thus clothing it with flame which heaves and tosses like the blaze of a conflagration.

This is the "chromosphere" (or chromatosphere, if one is fastidious as to the proper formation of a Greek derivative), a name first proposed by Frankland and Lockyer in 1869, and intended to signify

"color-sphere," in allusion to the vivid redness of the stratum caused by the predominance of hydrogen in these flames and clouds.

Here and there masses of this hydrogen mixed with other substances rise to a great height, ascending far above the general level into the coronal regions, where they float like clouds, or are torn to pieces by contending currents. These cloud-masses are known as solar "prominences," or "protuberances," a non-committal sort of appellation applied in 1842, when they first attracted any considerable attention, and while it was a warmly-disputed question whether they were solar, lunar, phenomena of our own atmosphere, or even mere optical illusions. It is unfortunate that no more appropriate and graphic name has yet been found for objects of such wonderful beauty and interest.

Until recently, the solar atmosphere could be seen only when the sun itself was hidden by the moon, a few minutes in a century. Now, however, the spectroscope has brought the chromosphere and the prominences within the range of daily observation, so that they can be studied with nearly the same facility as the spots and faculæ, and a fresh field of great interest and importance is thus opened to science. But the corona as yet defies the new method, and can be seen only during the fleeting moments of a solar eclipse.

It seems hardly possible that the ancients should have failed to notice, even with the naked eye, in some one of the many eclipses on record, the presence of blazing star-like objects around the edge of the moon, but we find no mention of any thing of the kind, although the corona is described as we see it now. On this ground some have surmised that the sun has really undergone a change in modern times, and that the chromosphere and prominences are a new development in the solar history. But such mere negative evidence is altogether insufficient as a foundation for so important a conclusion.

The earliest recorded observation of the prominences is probably that of Vassenius, a Swedish astronomer, who, during the total eclipse of 1733, noticed three or four small pinkish clouds, entirely detached from the limb of the moon, and, as he supposed, floating in the lunar atmosphere. At that time this was the most natural interpretation of the appearance, since the fact that the moon is without atmosphere was not yet ascertained.

The Spanish admiral, Don Ulloa, in his account of the eclipse of 1778, describes a point of red light which made its appearance on the western limb of the moon about a minute and a quarter before the emergence of the sun. At first small and faint, it grew brighter and brighter until extinguished by the returning sunlight. He supposed that the phenomenon was caused by a hole or fissure in the body of the moon; but, with our present knowledge there can be no doubt that it was simply a prominence gradually uncovered by her motion.

The chromosphere seems to have been seen even earlier than the

prominences: thus Captain Stannyan, in a report on the eclipse of 1706, observed by him at Berne, noticed that the emersion of the sun was preceded by a blood-red streak of light, visible for six or seven seconds upon the western limb. Halley and Louville saw the same thing in 1715. Halley says that two or three seconds before the emersion a long and very narrow streak of a dusky but strong red light seemed to color the dark edge of the moon on the western edge where the sun was about to reappear. Louville's account agrees substantially, and he further describes the precautions he used to satisfy himself that the phenomenon was no mere optical illusion, nor due to any imperfection of his telescope.

In eclipses that followed that of 1733, the chromosphere and prominences seem to have attracted but little attention, even if they were observed at all. Something of the sort appears to have been noticed by Ferrers in 1806, but the main interest of his observation lay in a different direction.

In July, 1842, a great eclipse occurred, and the shadow of the moon described a wide belt running across Southern France, Northern Italy, and a portion of Austria. The eclipse was carefully observed by many of the most noted astronomers of the world, and so completely had previous observations of the kind been forgotten, that the prominences, which appeared then with great brilliance, were regarded with extreme surprise, and became objects of warm discussion, not only as to their cause and location, but even as to their very existence. Some thought them mountains upon the sun, some that they were solar flames, and others, clouds floating in the sun's atmosphere. Others referred them to the moon, and yet others claimed that they were mere optical illusions. At the eclipse of 1851 (in Sweden and Norway), similar observations were repeated, and, as a result of the discussions and comparison of observations which followed, astronomers generally became satisfied that the prominences are real phenomena of the solar atmosphere, in many respects analogous to our terrestrial clouds; and several came more or less confidently to the conclusion, now known to be true (*see* Grant's "History of Physical Astronomy"), that the sun is entirely surrounded with a continuous stratum of the same substance. Many, however, remained unconvinced: Faye, for instance, still asserted them to be mere optical illusions, or mirages.

In the eclipse of 1860, photography was for the first time employed on such an occasion with any thing like success. The results of Secchi and De La Rue removed all remaining doubts as to the real existence and solar character of the objects in question, by exhibiting them upon their plates gradually covered on one side and uncovered on the other side of the sun by the outward progress of the moon.

Secchi thus sums up his conclusions, which have been justified in almost all their details by later observations; they require few and slight corrections:

1. The prominences are not mere optical illusions; they are real phenomena pertaining to the sun. . . .

2. The prominences are collections of luminous matter of great brilliance, and possessing remarkable photographic activity. This activity is so great that many of them, which are visible in our photographs, could not be seen directly even with good instruments.

3. Some protuberances float entirely free in the solar atmosphere like clouds. If they are variable in form, their changes are so gradual as to be insensible in the space of ten minutes. (Generally, but by no means always, true.)

4. Besides the isolated and conspicuous protuberances there is also a layer of the same luminous substance which surrounds the whole sun, and out of which the protuberances rise above the general level of the solar surface. . . .

5. The number of the protuberances is indefinitely great. In direct observation through the telescope the sun appeared surrounded with flames too numerous to count. . . .

6. The height of the protuberances is very great, especially when we take account of the portion hidden by the moon. One of them had a height of at least three minutes, which indicates a real altitude of more than ten times the earth's diameter. . . .

But their nature still remained a mystery; and no one could well be blamed for thinking it must always remain so to some degree. At that time it could hardly be hoped that we should ever be able to ascertain their chemical constitution, and measure the velocities of their motions. And yet this has been done. Before the great Indian eclipse of August 18, 1868, the spectroscope had been invented (it was, indeed, already in its infancy in 1860), and applied to astronomical research with the most astonishing and important results.

Every one is more or less familiar with the story of this eclipse. Herschel, Tennant, Pogson, Rayet, and Janssen, all made substantially the same report. They found the spectrum of the prominences observed to consist of bright lines, and conspicuous among them were the lines of hydrogen. There were some serious discrepancies, indeed, among their observations, not only as to the number of the bright lines seen, which is not to be wondered at, but as to their position. Thus, Rayet (who saw more lines than any other) identified the red line observed with B instead of C; and all the observers mistook the yellow line they saw for that of sodium.

Still, their observations, taken together, completely demonstrated the fact that the prominences are enormous masses of highly-heated gaseous matter, and that hydrogen is a main constituent.

Janssen went further. The lines he saw during the eclipse were so brilliant that he felt sure he could see them again in the full sunlight. He was prevented by clouds from trying the experiment the same afternoon, after the close of the eclipse; but the next morning

the sun rose unobscured, and, as soon as he had completed the necessary adjustments, and directed his instrument to the portion of the sun's limb where the day before the most brilliant prominence appeared, the same lines came out again, clear and bright; and now, of course, there was no difficulty in determining at leisure, and with almost absolute accuracy, their position in the spectrum. He immediately confirmed his first conclusion, that hydrogen is the most conspicuous component of the prominences, but found that the yellow line must be referred to some different element than sodium, being somewhat more refrangible then the D lines.

He found also that, by slightly moving his telescope and causing the image of the sun's limb to take different positions with reference to the slit of his spectroscope, he could even trace out the form and measure the dimensions of the prominences; and he remained at his station for several days, engaged in these novel and exceedingly interesting observations.

Of course, he immediately sent home a report of his eclipse-work, and of his new discovery, but, as his station at Guntoor, in Eastern India, was farther from mail communication with Europe than those upon the western coast of the peninsula, his letter did not reach France until some week or two after the accounts of the other observers; when it did arrive, it came to Paris, in company with a communication from Mr. Lockyer, announcing the same discovery, made independently, and even more creditably, since with Mr. Lockyer it was not suggested by any thing he had seen, but was thought out from fundamental principles.

Nearly two years previously the idea had occurred to him (and, indeed, to others also, though he was the first to publish it), that if the protuberances are gaseous, so as to give a spectrum of bright lines, those lines ought to be visible in a spectroscope of sufficient power, even in broad daylight. The principle is simply this:

Under ordinary circumstances the protuberances are invisible, for the same reason as the stars, in the daytime: they are hidden by the intense light reflected from the particles of our own atmosphere near the sun's place in the sky, and, if we could only sufficiently weaken this aërial illumination, without at the same time weakening *their* light, the end would be gained. And the spectroscope accomplishes precisely this very thing. Since the air-light is reflected sunshine, it of course presents the same spectrum as sunlight, a continuous band of color crossed by dark lines. Now, this sort of spectrum is greatly weakened by every increase of dispersive power, because the light is spread out into a longer ribbon and made to cover a more extended area. On the other hand, a spectrum of bright lines undergoes no such weakening by an increase in the dispersive power of the spectroscope. The bright lines are only more widely separated—not in the least diffused or shorn of their brightness. If, then, the image of the sun, formed by

a telescope, be examined with a spectroscope, one might hope to see at the edge of the disk the bright lines belonging to the spectrum of the prominences, in case they are really gaseous.

Mr. Lockyer and Mr. Huggins both tried the experiment as early as 1867, but without success; partly because their instruments had not sufficient power to bring out the lines conspicuously, but more because they did not know whereabouts in the spectrum to look for them, and were not even sure of their existence. At any rate, as soon as the discovery was announced, Mr. Huggins immediately saw the lines without difficulty, with the same instrument which had failed to show them to him before. It is a fact, too often forgotten, that to perceive a thing known to exist does not require one-half the instrumental power or acuteness of sense as to discover it.

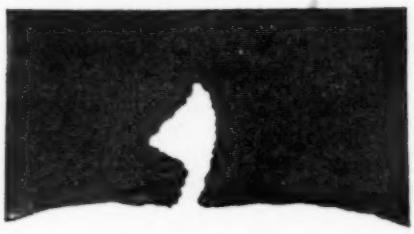
Mr. Lockyer, immediately after his suggestion was published, had set about procuring a suitable instrument, and was assisted by a grant from the treasury of the Royal Society. After a long delay, consequent in part upon the death of the optician who had first undertaken its construction, and partly due to other causes, he received the new spectroscope just as the report of Herschel's and Tennant's observations reached England. Hastily adjusting the instrument, not yet entirely completed, he at once applied it to his telescope, and without difficulty found the lines, and verified their position. He immediately also discovered them to be visible around the whole circumference of the sun, and consequently that the protuberances are mere extensions of a continuous solar envelope, to which, as mentioned above, was given the name of Chromosphere. (He does not seem to have been aware of the earlier and similar conclusions of Arago, Grant, Secchi, and others.) He at once communicated his results to the Royal Society, and also to the French Academy of Sciences, and, by one of the curious coincidences which so frequently occur, his letter and Janssen's were read at the same meeting, and within a few minutes of each other.

The discovery excited the greatest enthusiasm, and in 1872 the French Government struck a gold medal in honor of the two astronomers, bearing their united effigies.

It immediately occurred to several observers, Janssen, Lockyer, Zöllner, and others, that by giving a rapid motion of vibration or rotation to the slit of the spectroscope it would be possible to perceive the whole contour and detail of a protuberance at once, but it seems to have been reserved for Mr. Huggins to be the first to show practically that a still simpler device would answer the same purpose. With a spectroscope of sufficient dispersive power it is only necessary to widen the slit of the instrument by the proper adjusting screw. As the slit is widened, more and more of the protuberance becomes visible, and if not too large the whole can be seen at once: with the widening of the slit, however, the brightness of the background increases, so that the finer details of the object are less clearly seen, and a limit

is soon reached beyond which further widening is disadvantageous. The higher the dispersive power of the spectroscope the wider the slit that can be used, and the larger the protuberance that can be examined as a whole.

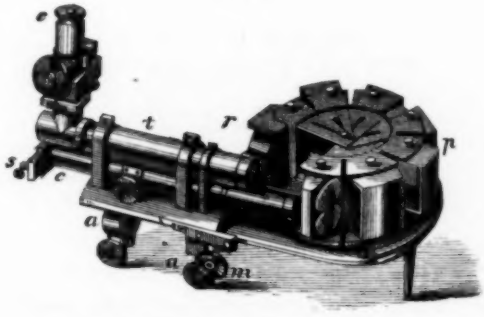
FIG. 1.



HUGGINS'S FIRST OBSERVATION OF A PROMINENCE IN FULL SUNSHINE.

Mr. Huggins's first successful observation of the form of a solar protuberance was made on February 13, 1869. Fig. 1, copied from the Proceedings of the Royal Society, presents his delineation of what he saw. As his instrument had only the dispersive power of two prisms, and included in its field of view a large portion of the spectrum at once, he found it necessary to supplement its powers by using a red glass to cut off stray light of other colors, and by inserting a diaphragm at the focus of the small telescope of the spectroscope to limit the field of view to the portion of the spectrum immediately adjoining the C line. With the instruments now in use, these precautions are seldom necessary.

FIG. 2.



SPECTROSCOPE, WITH TRAIN OF PRISMS.

It may be noticed, in passing, that Mr. Huggins had previously (and has subsequently) made many experiments with different absorbing media, in hopes of finding some substance which, by cutting off all light of other color than that emitted by the prominences, should render them visible in the telescope; thus far, however, without success.

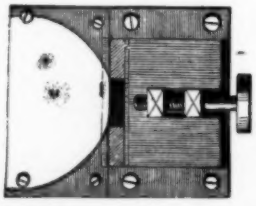
The spectroscopes used by different astronomers for observations of this sort differ greatly in form and power. Fig. 2 represents the

one employed at the Shattuck Observatory of Dartmouth College, and most of our American observatories are supplied with instruments similarly arranged. The light passes from the collimator *c*, through the train of prisms *p*, near their bases, and, by two reflections in a rectangular prism, *r*, is transferred to the upper story, so to speak, of the prism-train, and made to return to the telescope *t*, finally reaching the eye at *e*. It thus twice traverses a train of six prisms, and the dispersive power of the instrument is twelve times as great as it would be with only one prism. The diameter of the collimator is a little less than an inch, and its length 10 inches. The whole instrument, powerful as it is, only weighs about 14 pounds, and occupies a space of about 15 in. × 6 in. × 5 in. It is also *automatic*, i. e., the tangent screw *m* keeps the train of prisms adjusted to their position of minimum deviation by the same movement which brings the different portions of the spectrum to the centre of the field of view.

The spectroscope is attached to the equatorial telescope, to which it belongs, by means of the clamping rings *a*, *a*. These slide upon a stout metal rod, firmly fastened to the telescope in such a way that the slit *s*, of the instrument, can be placed exactly at the focus of the object-glass, where the image of the sun is formed.[1]

The telescope is directed so that the solar image shall fall with that portion of its limb which is to be examined just tangent to the opened slit, as in Fig. 3, which represents the slit-plate of the spectroscope of its actual size, with the image of the sun in position for observation just touching the rectangular opening formed on widening the slit by its adjusting screw.

FIG. 3.



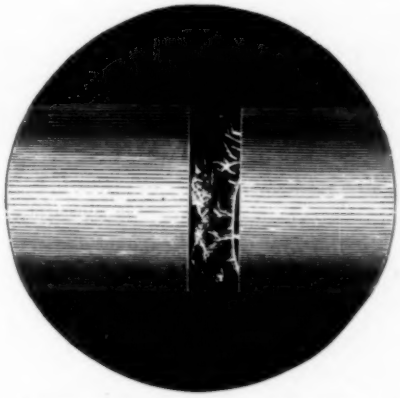
OPENED SLIT OF THE SPECTROSCOPE.

If, now, a prominence exists at this part of the sun's limb (as would probably be the case, considering the proximity of the spot shown in Fig. 3), and if the spectroscope itself is so adjusted that the C line falls in the centre of the field of view, then, on looking into the eye-piece, one will see something much like Fig. 4. The red portion of the

[1] The writer has recently found that a so-called diffraction-grating may take the place of the train of prisms in spectroscopes designed for simply viewing the prominences. With a grating ruled upon speculum metal, having 6,480 lines to the inch (for which he is indebted to the skill and kindness of Mr. Rutherfurd), he is able to observe the forms and motions of these objects nearly as well as with the spectroscope described in the text.

spectrum will stretch athwart the field of view like a scarlet ribbon, with a darkish band across it, and in that band will appear the prominences, like scarlet clouds; so like our own terrestrial clouds, indeed, in form and texture, that the resemblance is quite startling: one might almost think he was looking out through a partly-opened door upon a sunset sky, except that there is no variety or contrast of color; all the cloudlets are of the same pure scarlet hue. Along the edge of the opening is seen the chromosphere, more brilliant than the clouds which rise from it or float above it, and for the most part made up of minute tongues and filaments.

FIG. 4.



SPECTROSCOPIC ASPECT OF A PROMINENCE.

If the spectroscope is adjusted upon the F line, instead of C, then a similar image of the prominences and chromosphere is seen, only blue instead of scarlet; usually, however, this blue image is somewhat less perfect in its details and definition, and is therefore less used for observation. Similar effects are obtained by means of the yellow line near D, and the violet line near G. By setting the spectroscope upon this latter line and attaching a small camera to the eye-piece, it is even possible to photograph a bright protuberance; but the light is so feeble, the image so small, the time of exposure needed so long, and the requisite accuracy of motion in the clock-work which drives the telescope so difficult of attainment, that thus far no pictures of any real value have been obtained in this manner.

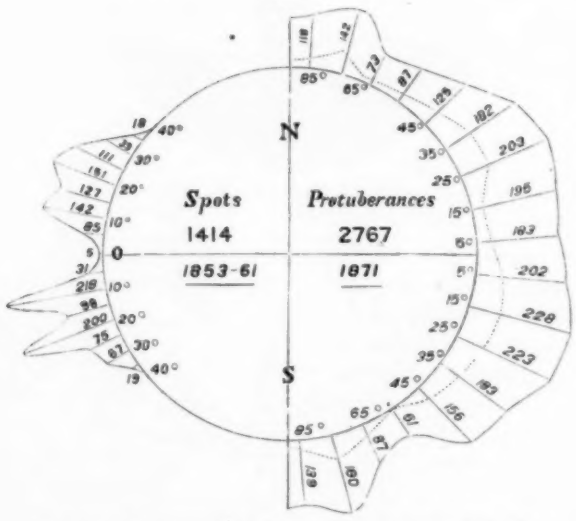
Prof. Winlock and Mr. Lockyer have attempted, by using, instead of the ordinary slit, an annular opening, to obtain a view of the whole circumference of the sun at once, and have partially succeeded. Undoubtedly, with a spectroscope of sufficient power, and adjustments delicate enough, the thing can be done; but as yet no very satisfactory results appear to have been reached. We are still obliged to examine the circumference of the sun piecemeal, so to speak, read-

justing the instrument at each point, to make the slit tangential to the limb.

The number of protuberances of considerable magnitude (exceeding 10,000 miles in altitude), visible at any one time on the circumference of the sun, is never very great, rarely reaching twenty-five or thirty; perhaps during the past few years it would most commonly lie between ten and twenty. At present, as the number of the spots decreases, the number of the prominences seems also to be diminishing, and within a few months there have been occasions when a careful search revealed only three or four.

Their distribution on the sun's surface is in some respects similar to that of the spots, but with important differences. The spots are confined within 40° of the sun's equator, being most numerous at a solar latitude of about 20° on each hemisphere. Now, the protuberances are most numerous precisely where the spots are most abundant, but they do not disappear at a latitude of 40°; they are found even at the poles, and from the latitude of 60° actually increase in number to a latitude of about 75°.

Fig. 5.



Relative Frequency of Protuberances and Sun-Spots.

The annexed diagram, Fig. 5, represents the relative frequency of the protuberances and spots on the different portions of the solar surface. On the left side is given the result of Carrington's observation of 1,414 spots between 1853 and 1861, and on the right the result of Secchi's observations of 2,767 [1] protuberances in 1871. The length of

[1] The 2,767 prominences are not all different ones. If any of the prominences observed on one day remained visible the next, they were recorded afresh; and, as a promi-

each radial line represents the number of spots or protuberances observed at each particular latitude on a scale of a quarter of an inch to the hundred; for example, Secchi gives 228 protuberances as the number observed during the period of his work between 10° and 20° of south latitude, and the corresponding line drawn at 15° south, on the left-hand side of the figure, is therefore made $\frac{228}{400}$ or .57 of an inch long. The other lines are laid off in the same way, and thus the irregular curve drawn through their extremities represents to the eye the relative frequency of these phenomena in the different solar latitudes. The dotted line on the right-hand side represents in the same manner and on the same scale the distribution of the larger protuberances, having an altitude of more than 1′, or 27,000 miles.

A mere inspection of the diagram shows at once that, while the prominences may, and in fact often do, have a close connection with the spots, they are entirely independent phenomena.

A careful study of the subject shows that they are much more closely related to the faculæ. In many cases at least, faculæ, when followed to the limb of the sun, have been found to be surrounded by prominences, and there is reason to suppose that the fact is a general one. The spots, on the other hand, when they reach the border of the sun's image, are commonly *surrounded* by prominences more or less completely, but seldom overlaid by them. Indeed, Respighi asserts (and the most careful observations we have been able to make confirm his statement) that as a general rule the chromosphere is considerably depressed immediately over a spot. Secchi, however, denies this.

The protuberances differ greatly in magnitude. The average depth of the chromosphere is not far from 10″ or 12″, or about 5,000 or 6,000 miles, and it is nŏt, therefore, customary to note as a prominence any cloud with an elevation of less than 15″ or 20″—7,000 to 9,000 miles. Of the 2,767 already quoted, 1,964 attained an altitude of 40″, or 18,000 miles, and it is worthy of notice that the smaller ones are so few, only about one-third of the whole: 751, or nearly one-fourth of the whole, reached a height of over 1′, or 28,000 miles; the precise number which reached greater elevations is not mentioned, but several exceeded 3′, or 84,000 miles. There are numerous instances on record, by different observers, of protuberances exceeding 100,000 miles, and a single instance, observed by the writer, in which the enormous altitude of 7′ 49″, or 211,000 miles, was attained.

In their form and structure the protuberances differ as widely as in their magnitude. Two principal classes are recognized by all observers, the *quiescent*, *cloud-formed*, or hydrogenous, and the *eruptive* or metallic. By Secchi these are each further subdivided into several

nence near the pole would be carried but slowly out of sight by the sun's rotation, it is thus easy to see how the number of prominences recorded in the polar regions is so large, notwithstanding the smaller area of each zone of 5° width, as compared with a similar zone near the equator.

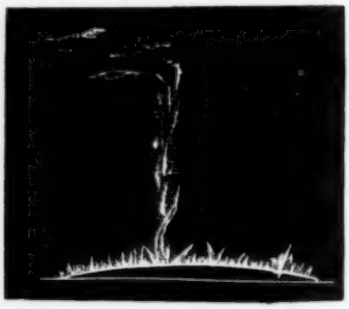
ERUPTIVE PROMINENCES.

Three figures, of the same prominence, seen July 25, 1872.

FIG. 6.

AS SEEN AT 2.15 P. M.

FIG. 7.

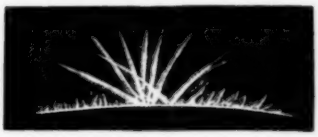


AS SEEN AT 2.45 P. M.

FIG. 8.

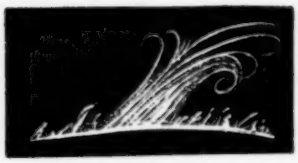
AS SEEN AT 3.30 P. M.
100,000 miles to the inch.

FIG. 9.



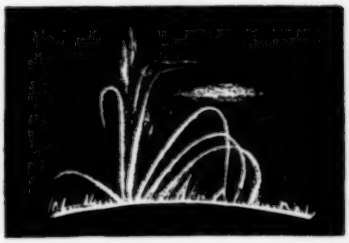
SPIKES.

FIG. 10.



SHEAF AND VOLUTES.

FIG. 11.



JETS.

sub-classes or varieties, between which, however, it is not always easy to maintain the distinctions.

The quiescent prominences in form and texture resemble, with almost perfect exactness, our terrestrial clouds, and differ among themselves as much and in the same manner. The familiar cirrus and stratus types are very common, the former especially, while the cumulus and cumulo-stratus are less frequent. The protuberances of this class are often of enormous magnitude, especially in their horizontal extent (but the highest elevations are attained by those of the eruptive order), and are comparatively permanent, remaining often for hours and days without serious change; near the poles they sometimes persist through a whole solar revolution of twenty-seven days.

Sometimes they appear to lie upon the limb of the sun like a bank of clouds in the horizon; probably because they are so far from the edge of the disk that only their upper portions are in sight. When seen in their full extent they are ordinarily connected to the underlying chromosphere by slender columns, which are usually smallest at the base, and appear often to be made up of separate filaments closely intertwined, and expanding upward. Sometimes the whole under surface is fringed with down-hanging filaments, which remind one of a summer shower falling from a heavy thunder-cloud. Sometimes they float entirely free from the chromosphere; indeed, as a general rule, the layer clouds are attended by detached cloudlets for the most part horizontal in their arrangement.

The figures give an idea of some of the general appearances of this class of prominences, but their delicate, filmy beauty can be adequately rendered only by a far more elaborate style of engraving.

Their spectrum is usually very simple, consisting of the four lines of hydrogen and the orange D^3—hence the appellation hydrogenous. Occasionally the sodium and magnesium lines also appear, and that even near the summit of the clouds; and this phenomenon was so much more frequently observed in the clear atmosphere of Sherman as to suggest that, if the power of our spectroscopes were sufficiently increased, it would cease to be unusual.

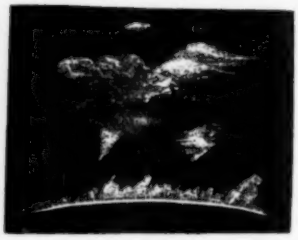
The genesis of this sort of prominence is problematical. They have been commonly looked upon as the *débris* and relics of eruptions, consisting of gases which have been ejected from beneath the solar surface, and then abandoned to the action of the currents of the sun's upper atmosphere. But near the poles of the sun distinctively eruptive prominences never appear, and there is no evidence of aërial currents which would transport to those regions matters ejected nearer the sun's equator. Indeed, the whole appearance of these objects indicates that they originate where we see them. Possibly, although in the polar regions there are no violent eruptions, there yet may be a quiet outpouring of heated hydrogen sufficient to account for their production—an outrush issuing through the smaller pores of the solar surface, which abound near the poles as well as elsewhere.

But Secchi reports an observation (not yet, however, confirmed by other spectroscopists, so far as we know) which, if correct, puts a very different face upon the matter. He has seen isolated cloudlets form and grow spontaneously without any perceptible connection with the chromosphere or other masses of hydrogen, just as in our own atmosphere clouds form from aqueous vapor, already present in the air, but invisible until some local cooling or change of pressure causes its condensation. Granting the correctness of the observation, these prominences are, therefore, formed by some local heating or other luminous excitement of hydrogen already present, and not by any transportation and aggregation of materials from a distance. The

QUIESCENT PROMINENCES.

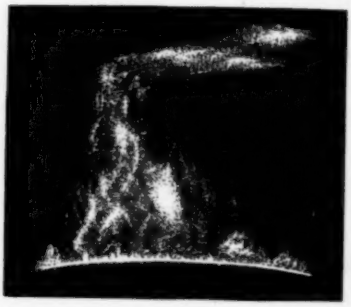
Scale, 75,000 miles to the inch.

FIG. 12.



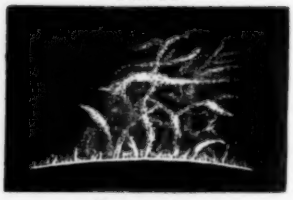
CLOUDS.

FIG. 15.



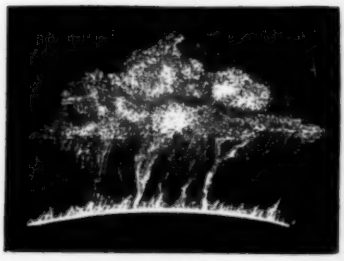
DIFFUSE.

FIG. 13.



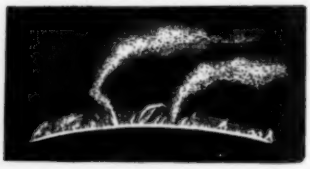
FILAMENTARY.

FIG. 16.



STEMMED.

FIG. 14.



PLUMES.

FIG. 17.

HORNS.

precise nature of the action which produces this effect it would not be possible to assign at present; but it is worthy of note that the observations of the eclipse of 1871, by Lockyer and others, rather favor this view, by showing that hydrogen, in a feebly luminous condition, is found all around the sun, and at a very great altitude—far above the ordinary range of prominences.

The eruptive prominences are very different, consisting usually of brilliant spikes or jets, which change their form and brightness very rapidly. For the most part they attain altitudes of not more than 20,000 or 30,000 miles, but occasionally they rise far higher than even

the largest of the clouds of the preceding class. Their spectrum is very complicated, especially near their base, and often filled with bright lines, those of sodium, magnesium, barium, iron, and titanium, being especially conspicuous, while calcium, chromium, manganese, and probably sulphur, are by no means rare, and for this reason Secchi calls them *metallic* prominences.

They usually appear in the immediate neighborhood of a spot, never occurring very near the solar poles. Their form and appearance change with great rapidity, so that the motion can almost be seen with the eye—an interval of fifteen or twenty minutes being often sufficient to transform, quite beyond recognition, a mass of these flames 50,000 miles high, and sometimes embracing the whole period of their complete development or disappearance. Sometimes they consist of pointed rays, diverging in all directions, like hedgehog spines. Sometimes they look like flames; sometimes like sheaves of grain; sometimes like whirling water-spouts, capped with a great cloud; occasionally they present most exactly the appearance of jets of liquid fire, rising and falling in graceful parabolas; frequently they carry on their edges spirals like the volutes of an Ionic column; and continually they detach filaments which rise to a great elevation, gradually expanding and growing fainter as they ascend, until the eye loses them. Our figures present some of the more common and typical forms, and illustrate their rapidity of change, but there is no end to the number of curious and interesting appearances which they exhibit under varying circumstances.

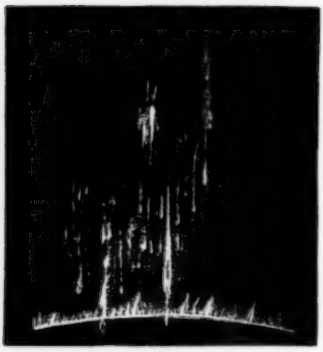
The velocity of the motions *often* exceeds 100 miles a second, and sometimes, though very rarely, reaches 200 miles. That we have to do with actual motions, and not with mere change of place of a luminous form, is rendered certain by the fact that the lines of the spectrum are often displaced and distorted in a manner to indicate that some of the cloud-masses are moving either toward or from the earth (and, of course, tangential to the solar surface) with similar swiftness.

When we come to inquire what forces impart such a velocity, the subject becomes difficult. If we could admit that the surface of the sun is solid, or even liquid, as Zöllner thinks, then it would be easy to understand the phenomena as eruptions, analogous to those of volcanoes on the earth, though on the solar scale. But it is next to certain that the sun is mainly gaseous, and that its luminous surface or photosphere is a sheet of incandescent clouds, like those of the earth, except that water-droplets are replaced by droplets of the metals; and it is difficult to see how such a shell could exert sufficient confining power upon the imprisoned gases to explain such tremendous velocity in the ejected matter.

Possibly the difficulty may be met by taking account of the enormous amount of condensation which must be going on within the photosphere. To supply the heat which the sun throws off (enough to melt

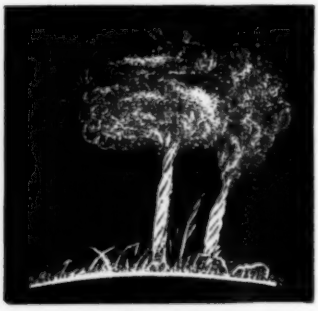
Scale, 75,000 miles to the inch.

FIG. 18.



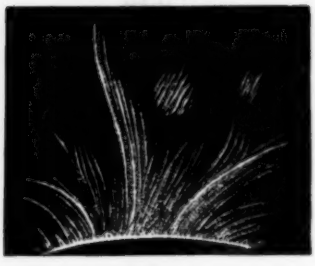
VERTICAL FILAMENTS.

FIG. 19.



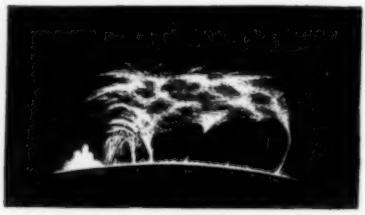
CYCLONE.

FIG. 20.



FLAMES.

FIG. 21.

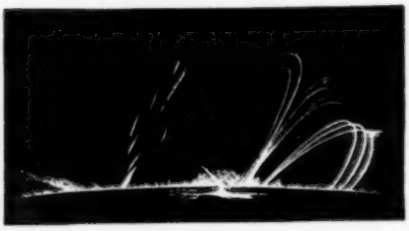


PROMINENCE AS IT APPEARED AT HALF-PAST TWELVE O'CLOCK, SEPTEMBER 7, 1871.

FIG. 22.

AS THE ABOVE APPEARED HALF AN HOUR LATER, WHEN THE UPRUSHING HYDROGEN ATTAINED A HEIGHT OF MORE THAN 200,000 MILES.

FIG. 23.



SPOT NEAR THE SUN'S LIMB, WITH ACCOMPANYING JETS OF HYDROGEN, AS SEEN OCTOBER 5, 1871.

each minute a shell of ice nearly forty feet thick over his entire surface) would require the condensation of enough vapor to make a sheet of liquid five feet thick in the same time—supposing, that is, the latent heat of the solar vapors not greater than that of water vapors. This, of course, is uncertain, but, so far as we know, very few if any vapors contain more latent heat than that of water, and we may therefore consider it roughly correct to estimate the continuous production of

liquid as measured by the quantity named. Now, on the surface of the earth a rain-storm which deposits two inches in an hour is very uncommon—in such a storm the water falls in sheets. It is easy to see, then, that the quantity of liquid pouring from the solar clouds is so enormous that the drops could not be expected to remain separate, but must almost certainly unite into more or less continuous masses or sheets, between and through which the gases ascending from beneath must make their way. And since the weight of the vapors which ascend must continually equal that of the products of condensation which are falling, it is further evident that the upward currents, rushing through contracted channels, must move with enormous velocity, and therefore, of course, that the pressure and temperature must rapidly increase from the free surface downward. It would seem that thus we might explain how the upper surface of the hydrogen atmosphere is tormented by the up-rush from below, and how gaseous masses, thrown up from beneath, should, in the prominences, present the appearances which have been described. Nor would it be strange if veritable explosions should occur in the quasi pipes or channels through which the vapors rise, when, under the varying circumstances of pressure and temperature, the mingled gases reach their point of combination; explosions which would fairly account for such phenomena as those represented on page 400, when clouds of hydrogen were thrown to an elevation of more than 200,000 miles with a velocity which *must* have exceeded at first 200 miles per second, and very probably, taking into account the resistance of the solar atmosphere, may, as Mr. Proctor has shown, have exceeded 500; a velocity sufficient to hurl a dense material entirely clear of the power of the sun's attraction, and send it out into space, never to return.

But our limits forbid indulgence in such speculations; nor can we stop to discuss the interesting question concerning the relation between these solar eruptions and magnetic storms upon the earth. It must suffice to say that, while it is not probable that our greater magnetic disturbances are caused directly by solar influence, it is very nearly certain that every violent paroxysm upon the sun is distinctly and immediately responded to by our magnetometers.

Whether these solar storms produce any other effects upon the earth, has not been ascertained. Some are so sanguine as to expect that in the study of these phenomena will be found the key to many puzzling problems of terrestrial meteorology. We cannot say that we share the expectation; but the subject is certainly worthy of careful examination, and it is not possible to doubt that faithful labor in so new and fertile a field will be rewarded, if not with precisely the result anticipated, yet with some rich harvest.

REPLIES TO CRITICISMS.

By HERBERT SPENCER.

II.

OBJECTIONS of another, though allied, class have been made in a review of the "Principles of Psychology," by Mr. H. Sidgwick—a critic whose remarks on questions of mental philosophy always deserve respectful consideration.

Mr. Sidgwick's chief aim is, to show what he calls "the mazy inconsistency of his [my] metaphysical results." More specifically he expresses thus the proposition he seeks to justify: "His view of the subject appears to have a fundamental incoherence, which shows itself in various ways on the surface of his exposition, but of which the root lies much deeper, in his inability to harmonize different lines of thought."

Before dealing with the reasons given for this judgment, let me say that, in addition to the value which candid criticisms have, as showing where more explanation is needed, they are almost indispensable as revealing to a writer incongruities he had not perceived. Especially where, as in this case, the subject-matter has many aspects, and where the words supplied by our language are so inadequate in number that, to avoid cumbrous circumlocution, they have to be used in senses that vary according to the context, it is extremely difficult to avoid imperfections of statement. But while I acknowledge sundry such imperfections and the resulting incongruities, I cannot see that these are, as Mr. Sidgwick says, fundamental. Contrariwise, their superficiality seems to me proved by the fact that they may be rectified without otherwise altering the expositions in which they occur. Here is an instance:

Mr. Sidgwick points out that, when treating of the "Data of Psychology," I have said (in § 56) that, though we reach inferentially "the belief that mind and nervous action are the subjective and objective faces of the same thing, we remain utterly incapable of seeing, and even of imagining, how the two are related" (I quote the passage more fully than he does). He then goes on to show that in the "Special Synthesis," where I have sketched the evolution of intelligence under its objective aspect, as displayed in the processes by which beings of various grades adjust themselves to surrounding actions, I "speak as if" we could see how consciousness "naturally arises at a particular stage" of nervous action. The chapter here referred to is one describing that "differentiation of the psychical from the physical life" which accompanies advancing organization, and more especially advancing development of the nervous system. In it I have aimed to show that, while the changes constituting physical life continue to be

characterized by the *simultaneity* with which all kinds of them go on throughout the organism, the changes constituting psychical life, arising as the nervous system develops, become more and more distinguished by their *seriality:* that with the advance of nervous integration "there must result an unbroken series of these changes—there must arise a consciousness." Now, I admit that here is an apparent inconsistency. I ought to have said that "there must result an unbroken series of these changes," which, taking place in the nervous system of a highly-organized creature, gives coherence to its conduct, and along with which we assume a consciousness, because consciousness goes along with coherent conduct in ourselves. If Mr. Sidgwick will substitute this statement for the statement as it stands, he will see that the arguments and conclusions remain intact. A survey of the chapter as a whole proves that its aim is not in the least to explain how nervous changes, considered as waves of molecular motion, become the feelings constituting consciousness; but that, contemplating the facts objectively in living creatures at large, it points out the cardinal distinction between vital actions in general, and those particular vital actions which, in a creature displaying them, lead us to speak of it as intelligent. It is shown that the rise of such actions becomes marked in proportion as the changes taking place in the part called the nervous system are made more and more distinctly serial, by union in a supreme centre of coördination. The introduction of the word consciousness arises in the effort to show what fundamental character there is in the physiological changes which is *parallel to* a fundamental character in the psychological changes.

Another instance of the way in which Mr. Sidgwick evolves an incongruity, which he considers fundamental, out of what I should have thought he would see is a defective expression, I will give in his own words. Speaking of a certain view of mine, he says:

"He tells us that 'logic . . . . contemplates in its propositions certain connections predicated, which are necessarily involved with certain other connections given: *regarding all these connections as existing in the non-ego*—not, it may be, under the form in which we know them, but in some form.' But in § 473, where Mr. Spencer illustrates by a diagram his 'Transfigured Realism,' the view seems to be this: although we cannot say that the real non-ego resembles our notion of it in 'its elements, relations, or laws,' we can say that 'a change in the objective reality causes in the subjective state a change exactly answering to it—so answering as to *constitute a cognition of it.*' Here the 'something beyond consciousness' is no longer said to be unknown, as its effect in consciousness 'constitutes a cognition of it.'"

This apparent inconsistency, marked by the italics, would not have existed, if, instead of "a cognition of it," I had said, as I ought to have done, "*what we call* a cognition of it"—that is, a relative cognition as distinguished from an absolute cognition. In ordinary language we speak of as cognitions those connections in thought which

so guide us in our dealings with things that actual experience verifies ideal anticipation. There is no direct resemblance whatever between the sizes, forms, colors, and arrangements, of the figures in an account-book, and the moneys or goods, debts or credits, represented by them; and yet the forms and arrangements of the written symbols are such as to answer in a perfectly exact way to stocks of various commodities and to various kinds of transactions. Hence we say, figuratively, that the account-book will "tell us" all about these stocks and transactions. Similarly, the diagram Mr. Sidgwick refers to illustrates the way in which symbols, registered in us by objects, may have forms and arrangements wholly unlike their objective causes and the *nexus* among those causes, while yet they are so related as to guide us correctly in our transactions with those objective causes, and *in that sense* constitute cognitions of them; though they no more constitute cognitions in the absolute sense than do the guiding symbols in the account-book constitute cognitions of the things to which they refer. So repeatedly is this view implied throughout the "Principles of Psychology," that I am surprised to find a laxity of expression raising the suspicion that I entertain any other.

To follow Mr. Sidgwick through sundry criticisms of like kind, which may be similarly met, would take more space than I can here afford. I must restrict myself now to that which he seems to regard as the "fundamental incoherence" of which these inconsistencies are signs. I refer to that reconciliation of Realism and Idealism considered by him as an impossible compromise. A difficulty is habitually felt in accepting a coalition after long conflict. Whoever has espoused one of two antagonist views, and, in defending it, has gained a certain comprehension of the opposite view, becomes accustomed to regard these as the only alternatives, and is puzzled by an hypothesis which is at once both and neither. Yet, since it turns out in nearly all cases, that of conflicting doctrines each contains an element of truth, and that controversy ends by combination of their respective half-truths, there is an *a priori* probability on the side of an hypothesis which qualifies Realism by Idealism.

Mr. Sidgwick expresses his astonishment, or rather bespeaks that of his readers, because, while I accept idealistic criticisms, I nevertheless defend the fundamental intuition of Common-Sense, and, as he puts it, "fires his [my] argument full in the face of Kant, Mill, and 'metaphysicians' generally."

"He tells us that 'metaphysicians' illegitimately assume that 'beliefs reached through complex intellectual processes' are more valid than 'beliefs reached through simple intellectual processes;' that the common language they use refuses to express their hypotheses, and thus their reasoning inevitably implies the common notions which they repudiate; that the belief of Realism has the advantage of 'priority,' 'simplicity,' 'distinctness.' But surely this prior, simple, distinctly affirmed belief is that of what Mr. Spencer terms 'crude Realism,'

the belief that the non-ego is *per se* extended, solid, even colored (if not resonant and odorous). This is what common language implies; and the argument by which Mr. Spencer proves the relativity of feelings and relations, still more the subtile and complicated analysis by which he resolves our notion of extension into an aggregate of feelings and transitions of feeling, leads us away from our original simple belief—that, e. g., the green grass we see exists out of consciousness as we see it—just as much as the reasonings of Idealism, Skepticism, or Kantism."

On the face of it the anomaly seems great; but I should have thought that, after reading the chapter on "Transfigured Realism," a critic of Mr. Sidgwick's accuteness would have seen the solution of it. He has overlooked an essential distinction. All which my argument implies is that the direct intuition of Realism must be held of superior authority to the arguments of Anti-Realism, *where their deliverances cannot be reconciled.* The one point on which their deliverances cannot be reconciled is, the existence of an objective reality. But, while, against this intuition of Realism, I hold the arguments of Anti-Realism to be powerless, because they cannot be carried on without postulating that which they end by denying, yet, having admitted objective existence as a necessary postulate, it is possible to make valid criticisms upon all those judgments which Crude Realism joins with this primordial judgment: it is possible to show that a transfigured interpretation of properties and relations is more tenable than the original interpretation.

To elucidate the matter, let us take the most familiar case in which the indirect judgments of Reason correct the direct judgments of Common-Sense. The direct judgment of Common-Sense is that the Sun moves round the Earth. In course of time, Reason finds certain difficulties in accepting this *dictum* as true. Eventually, Reason hits upon an hypothesis which explains the anomalies, but which denies this apparently certain *dictum* of Common-Sense. What is the reconciliation? It consists in showing to Common-Sense a mode of interpretation which equally well corresponds with direct intuition, while it avoids all the difficulties. Common-Sense is reminded that the apparent motion of an object may be due either to its actual motion or to the motion of the observer; and that there are terrestrial experiences in which the observer thinks an object he looks at is moving, when the motion is in himself. Extending the conception thus given, Reason shows that, if the Earth revolves on its axis, there will result that apparent motion of the Sun which Common-Sense interpreted into an actual motion of the Sun; and the common-sense observer becomes thereupon able to think of sunrise and sunset as consequent on his position as a spectator on a vast revolving globe. Now, if the astronomer, setting out by recognizing these celestial appearances, and proceeding to evolve the various anomalies following from the common-sense interpretation of them, had drawn the conclusion that

there externally exist no Sun and no motion at all, he would have done what idealists do; and his arguments would have been equally powerless against the intuition of Common-Sense. But he does nothing of the kind. He accepts the intuition of Common-Sense respecting the reality of the Sun and the motion; but replaces the old interpretation of it by a new interpretation reconcilable with all the facts.

Just in the same way that, here, acceptance of the inexpugnable element in the Common-Sense judgment by no means involves acceptance of the accompanying judgments, so, in the case of Crude Realism, it does not follow that, while against the consciousness of an objective reality the arguments of Anti-Realism are utterly futile, they are therefore futile against the conceptions which Crude Realism forms of the objective reality. If Anti-Realism can show that, granting an objective reality, the interpretation of Crude Realism contains insuperable difficulties, the process is quite legitimate. And, its primordial intuition remaining unshaken, Realism may, on reconsideration, be enabled to frame a new conception which harmonizes with all the facts.

To show that there is not here the "mazy inconsistency" alleged, let us take the case of sound as interpreted by Crude Realism, and as reinterpreted by Transfigured Realism. Crude Realism assumes the sound present in consciousness to exist as such beyond consciousness. Anti-Realism proves the inadmissibility of this assumption in sundry ways (all of which, however, set out by talking of sounding bodies beyond consciousness, just as Realism talks of them); and then Anti-Realism concludes that we know of no existence save the sound as a mode of consciousness: which conclusion and all kindred conclusions, I contend, are vicious—first, because all the words used connote an objective activity; second, because the arguments are impossible without postulating at the outset an objective activity; and third, because no one of the intuitions, out of which the arguments are built, is of equal validity with the single intuition of Realism that an objective activity exists. But, now, the Transfigured Realism which Mr. Sidgwick thinks "has all the serious incongruity of an intense metaphysical dream" neither affirms the untenable conception of Crude Realism, nor, like Anti-Realism, draws unthinkable conclusions by suicidal arguments; but, accepting that which is essential in Crude Realism, and admitting the difficulties which Anti-Realism insists upon, reconciles matters by a reinterpretation analogous to that which an astronomer makes of the solar motion. Continuing all along to recognize an objective activity which Crude Realism calls sound, it shows that the sensation is produced by a succession of separate impacts which, if made slowly, may be separately identified, and which will, if progressively increased in rapidity, produce tones higher and higher in pitch. It shows by other experiments that sounding

bodies are in states of vibration, and that the vibration may be made visible. And it concludes that the objective activity is not what it subjectively seems, but is proximately interpretable as a succession of aërial waves. Thus Crude Realism is shown that while there unquestionably exists an objective activity corresponding to the sensation known as sound, yet the facts are not explicable on the original supposition that this is like the sensation; while they are explicable by conceiving it as a rhythmical mechanical action. Eventually this reinterpretation, joined with kindred reinterpretations of other sensations, comes to be itself further transfigured by analysis of its terms, and reëxpression of them in terms of molecular motion; but, however abstract the interpretation ultimately reached, the objective activity continues to be postulated: the primordial judgment of Crude Realism remains unchanged, though it has to change the rest of its judgments.

In another part of his argument, however, Mr. Sidgwick implies that I have no right to use those conceptions of objective existence by which this compromise is effected. Quoting sundry passages to show that, while I hold the criticisms of the Idealist to be impossible without "tacitly or avowedly postulating an unknown something beyond consciousness," I yet admit that "our states of consciousness are the only things we can know," he goes on to argue that I am radically inconsistent, because, in interpreting the phenomena of consciousness, I continually postulate not an unknown something, but a something of which I speak in ordinary terms, as though its ascribed physical characters really exist as such, instead of being, as I admit they are, synthetic states of my consciousness. His objection, if I understand it, is, that, for the purposes of Objective Psychology, I apparently profess to know Matter and Motion in the ordinary realistic way; while, as a result of subjective analysis, I reach the conclusion that it is impossible to have that knowledge of objective existence which Crude Realism supposes we have. Doubtless there seems here to be what he calls "a fundamental incoherence." But I think it exists, not between my two expositions, but between the two consciousnesses of subjective and objective existence, which we cannot suppress and yet cannot put into definite forms. The alleged incoherence I take to be but another name for the inscrutability of the relation between subjective feeling and its objective correlate which is not feeling—an inscrutability which meets us at the bottom of all our analyses. An exposition of this inscrutability I have elsewhere summed up thus:

"See, then, our predicament. We can think of Matter only in terms of Mind. We can think of Mind only in terms of Matter. When we have pushed our explorations of the first to the uttermost limit, we are referred to the second for a final answer; and, when we have got the final answer of the second, we are referred back to the first for an interpretation of it. We find the value of x in terms

of y; then we find the value of y in terms of x; and so on we may continue forever without coming nearer to a solution."—(*Principles of Psychology*, § 272.)

Carrying a little further this simile, will, I think, show where lies the insuperable difficulty felt by Mr. Sidgwick. Taking x and y as the subjective and objective activities, unknown in their natures and known only as phenomenally manifested, and recognizing the fact that every state of consciousness implies, immediately or remotely, the action of object on subject, or subject on object, or both, we may say that every state of consciousness will be symbolized by some modification of $x\ y$—the phenomenally-known product of the two unknown factors. In other words, xy', $x'y$, $x'y'$, $x''y'$, $x'y''$, etc., etc., will represent all perceptions and thoughts. Suppose, now, that these are thoughts about the object; composing some hypothesis respecting its character as analyzed by physicists. Clearly, all such thoughts, be they about shapes, resistances, momenta, molecules, molecular motions, or what not, will contain some form of the subjective activity x. Now, let the thoughts be concerning mental processes. It must similarly happen that some mode of the unknown objective activity, y, will be in every case a component. Now, suppose that the problem is the genesis of mental phenomena, and that, in the course of the inquiry, bodily organization and the functions of the nervous system are brought into the explanation. It will happen, as before, that these, considered as objective, have to be described and thought about in modes of $x\ y$. And when by the actions of such a nervous system, conceived objectively in modes of $x\ y$, and acted upon by physical forces which are conceived in other modes of $x\ y$, we endeavor to explain the genesis of sensations, perceptions, and ideas, which we can think of only in other modes of $x\ y$, we find that all our factors, and therefore all our interpretations, contain the two unknown terms, and that no interpretation is imaginable that will not contain the two unknown terms.

What is the defense for this apparently circular process? Simply that it is a process of establishing *congruity* among our symbols. It is the finding a mode of so symbolizing the unknown activities subjective and objective, and so operating with our symbols, that all our acts may be rightly guided—guided, that is, in such ways that we can anticipate when, where, and in what quantity, one of our symbols will be found. Mr. Sidgwick's difficulty arises, I think, from having insufficiently borne in mind the statements made at the outset, in "The Data of Philosophy," that such conceptions as "are vital, or cannot be separated from the rest without mental dissolution, must be assumed true *provisionally*;" that "there is no mode of establishing the validity of any belief except that of showing its entire *congruity* with all other beliefs," and that "Philosophy, compelled to make those fundamental assumptions without which thought is impossible,

has to justify them by showing their *congruity* with all other dicta of consciousness." In pursuance of this distinctly-avowed mode of procedure, I assume as true, provisionally, certain modes of formulating the manifestations of the unknown objective activity, certain modes of formulating the manifestations of the unknown subjective activity, and certain resulting modes of conceiving the operations of the one on the other. These provisional assumptions having been carried out to all their consequences, and these consequences proved to be congruous with one another and with the original assumptions, these original assumptions are justified; and, if, finally, I assert, as I have repeatedly asserted, that the terms in which I express my assumptions and carry on my operations are but symbolic, and that all I have done is to show that, by certain ways of symbolizing, perfect harmony results — invariable agreement between the symbols in which I frame my expectations and the symbols which occur in experience—I cannot be blamed for incoherence. Lastly, should it be said that this regarding of every thing constituting experience and thought as symbolic has a very shadowy aspect, I reply that these which I speak of as symbols are real relatively to our consciousness, and are symbolic only in their relation to the Ultimate Reality.

That these explanations will make clear the coherence of views which before seemed "fundamentally incoherent," I feel by no means certain; since, as I did not perceive the difficulties presented by the exposition as at first made, I may similarly fail to perceive the difficulties in this explanation. Originally, I had intended to complete the "Principles of Psychology" by a division showing how the results reached in the preceding divisions, physiological and psychological, analytic and synthetic, subjective and objective, harmonized with one another, and were but different aspects of the same aggregate of phenomena. But the work was already bulky; and I concluded that this division might be dispensed with, because the congruities to be pointed out were sufficiently obvious. So little was I conscious of the alleged "inability to harmonize different lines of thought." Mr. Sidgwick's perplexities, however, show me that such an exposition of concords is needful.

I have reserved to the last one of the first objections made to the metaphysico-theological doctrine set forth in "First Principles," and implied in the several volumes that have succeeded it. I refer to one urged by an able metaphysician, the Rev. James Martineau, in an essay entitled "Science, Nescience, and Faith," and which, effective against my argument as it stands, shows the need for some further development of my argument. That Mr. Martineau's criticism may be understood, I must quote the passages it concerns. Continuing the reasoning employed against Hamilton and Mansel, to show that our consciousness of that which transcends knowledge is *positive*, and not, as they allege, *negative*, I have said:

"Still more manifest will this truth become when it is observed that our conception of the Relative itself disappears, if our conception of the Absolute is a pure negation. It is admitted, or rather it is contended, by the writers I have quoted above, that contradictories can be known only in relation to each other—that Equality, for instance, is unthinkable apart from its correlative Inequality; and that thus the Relative can itself be conceived only by opposition to the Non-relative. It is also admitted, or rather contended, that the consciousness of a relation implies a consciousness of both the related members. If we are required to conceive the relation between the Relative and Non-relative without being conscious of both, 'we are in fact (to quote the words of Mr. Mansel differently applied) required to compare that of which we are conscious with that of which we are not conscious; the comparison itself being an act of consciousness, and only possible through the consciousness of both its objects.' What, then, becomes of the assertion that 'the Absolute is conceived merely by a negation of conceivability,' or as 'the mere absence of the conditions under which consciousness is possible?' If the Non-relative or Absolute is present in thought only as a mere negation, then the relation between it and the Relative becomes unthinkable, because one of the terms of the relation is absent from consciousness. And if this relation is unthinkable, then is the Relative itself unthinkable, for want of its antithesis: whence results the disappearance of all thought whatever."—(*First Principles*, § 26.)

On this argument Mr. Martineau comments as follows; first restating it in other words:

"Take away its antithetic term, and the relative, thrown into isolation, is set up as absolute, and disappears from thought. It is indispensable, therefore, to uphold the Absolute in existence, as condition of the relative sphere which constitutes our whole intellectual domain. Be it so; but, when saved on this plea—to preserve the balance and interdependence of two *co*-relatives—the 'Absolute' is absolute no more; it is reduced to a term of relation; it loses therefore its exile from thought; its disqualification is canceled; and the alleged nescience is discharged.

"So, the same law of thought which warrants the existence, dissolves the inscrutableness, of the Absolute."—(*Essays, Philosophical and Theological*, pp. 186, 187.)

I admit this to be a telling rejoinder; and one which can be met only when the meanings of the words, as I have used them, are carefully discriminated, and the implications of the doctrine fully traced out. We will begin by clearing the ground of minor misconceptions.

First, let it be observed that, though I have used the word Absolute as the equivalent of Non-relative, because it is used in the passages quoted from the writers I am contending against, yet I have myself chosen for the purposes of my argument the name Non-relative, and I do not necessarily commit myself to any propositions respecting the Absolute, considered as that which includes both Subject and Object. The Non-relative, as spoken of by me, is to be understood rather as the totality of Being *minus* that which constitutes the individual consciousness, present to us under forms of Relation. Did I use the word in some Hegelian sense, as comprehensive of that which thinks

and that which is thought about, and did I propose to treat of the order of things, not as phenomenally manifested but as noumenally proceeding, the objection would be fatal. But, the aim being simply to formulate the order of things as present under relative forms, the antithetical Non-relative here named as implied by the conception of the Relative is that which, in any act of thought, is independent of and beyond it, rather than which is inclusive of it. Further, it should be observed that this Non-relative, spoken of as a necessary complement to the Relative, is not spoken of as a conception but as a *consciousness;* and I have in sundry passages distinguished between those modes of consciousness which, having limits, and constituting thought proper, are subject to the laws of thought, and the mode of consciousness which persists when the removal of limits is carried to the uttermost, and when distinct thought consequently ceases.

This opens the way to the reply here to be made to Mr. Martineau's criticism, namely: that while by the necessities of thought the Relative implies a Non-relative; and while, to think of this antithesis completely, requires that the Non-relative shall be made a conception proper; yet, for the vague thought which is alone in this case possible, it suffices that the Non-relative shall be present as a consciousness which though undefined is positive. Let us observe what necessarily happens when thought is employed on this ultimate question.

In a preceding part of the article criticised, I have, in various ways, aimed to show that, alike when we analyze the product of thought and when we analyze the process of thought, we are brought to the conclusion that invariably "a thought involves *relation, difference, likeness;*" and that, even from the very nature of Life itself, we may evolve the conclusion that, "thinking being relationing, no thought can ever express more than relations." What now must happen if thought, having this law, occupies itself with the final mystery? Always implying terms in relation, thought implies that both terms shall be more or less defined; and, as fast as one of them becomes indefinite, the relation also becomes indefinite, and thought becomes indistinct. Take the case of magnitudes. I think of an inch; I think of a foot; and, having tolerably definite ideas of the two, I have a tolerably definite idea of the relationship between them. I substitute for the foot a mile; and, being able to represent a mile much less definitely, I cannot so definitely think of the relation between an inch and a mile—cannot distinguish it in thought from the relation between an inch and two miles, as clearly as I can distinguish in thought the relation between an inch and one foot from the relation between an inch and two feet. And now if I endeavor to think of the relation between an inch and the 240,000 miles from here to the moon, and the relation between an inch and the 92,000,000 miles from here to the sun, I find that while these distances, practically inconceivable, have become little more than numbers to which I frame no answering ideas, so, too, have

the relations between an inch and either of them become practically inconceivable. Now, this partial failure in the process of forming thought-relations, which happens even with finite magnitudes when one of them becomes immense, becomes complete failure when one of the magnitudes cannot be brought within any limits. The relation itself becomes unrepresentable at the same time that one of its terms becomes unrepresentable. Nevertheless, in this case it is to be observed that the almost blank form of relation preserves a certain qualitative character. It is still distinguishable as belonging to the consciousness of extensions, not to the consciousnesses of forces or durations; and in so far remains a vaguely-identifiable relation. But now suppose we ask what happens when one term of the relation has not simply magnitude having no known limits, and duration of which neither beginning nor end is cognizable, but is also an existence not to be defined? In other words, what must happen if one term of the relation is not only quantitatively but also qualitatively unrepresentable? Clearly in this case the relation does not simply cease to be thinkable except as a relation of a certain class, but it lapses completely. When one of the terms becomes wholly unknowable, the law of thought can no longer be fulfilled; both because one term cannot be present, and because at the same time relation itself cannot be framed. That is to say, the law of thought, that contradictories can be known only in relation to each other, fails when thought attempts to transcend the Relative; and yet, when it attempts to transcend the Relative, it must make the attempt in conformity with its law—must in some dim mode of consciousness posit a Non-relative, and, in some similarly dim mode of consciousness, a relation between it and the Relative. In brief, then, to Mr. Martineau's objection I reply, that the insoluble difficulties he indicates arise here, as elsewhere, when thought is applied to that which transcends the sphere of thought; and that, just as, when we try to pass beyond phenomenal manifestations to the Ultimate Reality manifested, we have to symbolize it out of such materials as the phenomenal manifestations give us, so we have simultaneously to symbolize the connection between this Ultimate Reality and its manifestations as somehow allied to the connections among the phenomenal manifestations themselves. The truth Mr. Martineau's criticism adumbrates is, that the law of thought fails where the elements of thought fail; and this is a conclusion quite conformable to the general view I defend. Still holding the validity of my argument against Hamilton and Mansel, that in pursuance of their own principle the Relative is not at all thinkable as such, unless in contradistinction to some existence posited, however vaguely, as the other term of a relation conceived, however indefinitely, it is, I think, consistent on my part to hold that, in this effort which thought inevitably makes to pass beyond its sphere, not only does the product of thought become a dim symbol of a product, but the process of thought becomes a dim

symbol of a process; and hence any predicament inferable from the law of thought cannot be asserted.

I may fitly close this reply by a counter-criticism. To the direct defense of a proposition, there may be added the indirect defense that results from showing the untenability of an alternative proposition. This criticism on the doctrine of an unknowable existence, manifested to us in phenomena, Mr. Martineau makes in the interests of the doctrine held by him, that this existence is, to a considerable degree, knowable. We are quite at one in holding that there is an indestructible consciousness of Power behind Appearance; but, whereas I contend that this Power cannot be brought within the forms of thought, Mr. Martineau contends that there can be consistently ascribed certain attributes of personality—not, indeed, human characteristics so concrete as were ascribed in past times; but still, human characteristics of the more abstract and higher class. Regarding matter as independently existing; regarding, as also independently existing, those primary qualities of Body "which are inseparable from the very idea of Body, and may be evolved *a priori* from the consideration of it as solid extension or extended solidity;" and saying that to this class "belong Triple Dimension, Divisibility, and Incompressibility;" Mr. Martineau goes on to say that as these

> "cannot absent themselves from Body, they have a reality coeval with it, and belong eternally to the material datum objective to God; and his mode of activity with regard to them must be similar to that which alone we can think of his directing upon the relations of space, viz., not Volitional, to cause them, but Intellectual, to think them out. The Secondary Qualities, on the other hand, having no logical tie to the Primary, but, being appended to them as contingent facts, cannot be referred to any deductive thought, but remain over as products of pure Inventive Reason and Determining Will. This sphere of cognition *a posteriori* to us—where we cannot move a step alone, but have submissively to wait upon experience—is precisely the realm of Divine originality: and we are most sequacious where He is most free. While on this Secondary field his Mind and ours are thus contrasted, they meet in resemblance again upon the Primary; for the evolutions of deductive Reason there is but one track possible to all intelligences; no *merum arbitrium* can interchange the false and true, or make more than one geometry, one scheme of pure Physics for all worlds; and the Omnipotent Architect himself, in realizing the Cosmical conception, in shaping the orbits out of immensity and determining seasons out of eternity, could but follow the laws of curvature, measure, and proportion."—(*Essays, Philosophical and Theological*, pp. 163, 164.)

Before the major criticism which I propose to make on this hypothesis, let me make a minor one. Not only of space relations, but also of primary physical properties, Mr. Martineau asserts the necessity: not a necessity to our minds simply, but an ontological necessity. What is true for human thought, is, in respect of these, true absolutely: "the laws of curvature, measure, and proportion," as we know them, are unchangeable even by Divine power; as are also the

Divisibility and Incompressibility of Matter. But, if, in these cases, Mr. Martineau holds that a necessity in thought implies an answering necessity in things, why does he refrain from saying the like in other cases? Why, if he tacitly asserts it in respect of space-relations and the statical attributes of Body, does he not also assert it in respect of the dynamical attributes of Body? The laws conformed to by that mode of force now distinguished as "energy" are as much necessary to our thought as are the laws of space-relations. The axioms of Mechanics lie on the same plane with the axioms of pure Mathematics. Now, if Mr. Martineau admits this, as he cannot but do—if he admits, as he must, the corollary that there can be no such manifestation of energy as that displayed in the motion of a planet, save at the expense of equivalent energy which preëxisted—if he draws the further necessary corollary that the direction of a motion cannot be changed by any action, without an equal reaction in an opposite direction on something acting—if he bears in mind that this holds not only of all visible motions, celestial and terrestrial, but that those activities of Body which affect us as secondary properties are also known only through other forms of energy which are equivalents of mechanical energy—and if, lastly, he infers that none of these derivative energies can have given to them their characters and directions, save by preëxisting forces, statical and dynamical, conditioned in special ways—what becomes of that "realm of a Divine originality" which Mr. Martineau describes as remaining within the realm of necessity? Consistently carried out, his argument implies a universally-inevitable order, in which volition can have no such place as that he alleges.

Not pushing Mr. Martineau's reasoning to this conclusion, so entirely at variance with the one he draws, but accepting his statement just as it stands, let us consider the solution it offers us. We are left by it without any explanation of Space and Time; we are not helped in conceiving the origin of Matter; and there is afforded us no idea how Matter came to have its primary attributes. All these are tacitly assumed to exist uncreated. Creative activity is represented as under the restrictions imposed by mathematical principles, and as having for datum (mark the word) a substance which, in respect of certain characters, defies modification. But surely this is not an interpretation of the mystery of things. The mystery is simply relegated to a remoter region, respecting which no inquiry is to be made. But the inquiry *must* be made. After every such solution there arises afresh the question, What are the origin and nature of that which imposes these limits on creative power? what is the primary God which dominates over this secondary God? For, clearly, if the "Omnipotent Architect himself" (to use Mr. Martineau's somewhat inconsistent name) is powerless to change the "material datum objective" to him, and powerless to change the conditions under which it exists, and under

which he works, there is obviously implied a power to which he is subject. So that, in Mr. Martineau's doctrine also, there is an Ultimate Unknowable; and it differs from the doctrine he opposes only by intercalating a partially Knowable between this and the wholly Knowable.

Finding, as explained above, that this interpretation is not consistent with itself, and finding, as just shown, that it leaves the essential mystery unsolved, I do not see that it has an advantage over the doctrine of the Unknowable in its unqualified shape. There cannot, I think, be more than temporary rest in a proximate solution which takes for its basis an ultimate insolubility. Just as thought cannot be prevented from passing beyond Appearance, and trying to conceive the Cause behind, so, following out the interpretation Mr. Martineau offers, thought cannot be prevented from asking what Cause it is which restricts the Cause he assigns. And if we must admit that the question under this eventual form cannot be answered, may we not as well confess that the question under its immediate form cannot be answered? Is it not better candidly to acknowledge the incompetence of our intelligence, rather than to persist in calling that an explanation which does but disguise the inexplicable? Whatever answer each may give to this question, he cannot rightly blame those who, finding in themselves an indestructible consciousness of an Ultimate Cause, whence proceed alike what we call the Material Universe and what we call Mind, refrain from affirming any thing respecting it, because they find it as inscrutable in nature as it is inconceivable in extent and duration.

MODERN OPTICS AND PAINTING.[1]

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LECTURE I.

MODERN science has taught us that the portion of the material universe with which we are acquainted is swept from end to end by vibrations, that we are immersed in a sea whose very substance is constantly pulsating under the influence of systems and counter-systems of waves, and that even our very sensations are largely dependent on the action of these undulations upon ourselves. Now, the laws which rule these waves, comparatively speaking, are few and simple; the waves, taken by themselves, are modes of motion which are moderately intelligible; they obey well-known mechanical laws, and can be subjected to ordinary methods of computation. But, when we come to consider their action on living beings, the case is quite

[1] Two lectures delivered before the National Academy of Design.

altered; the effects are strange, unexpected, and the method of their production involved in mystery.

Let me take some examples, and the first shall be a coarse, rough one, involving powerful effects and sensations. If, by the aid of properly-contrived machinery, we communicate merely to the hand fifty or sixty energetic vibrations in a second, a peculiar and powerful sensation is produced, resembling that of a prolonged electric shock, and at the same time the hand becomes clinched, and cannot be opened by an effort of the will. In this experiment the vibrations are communicated to the hand by direct contact with a solid piece of metal. Let us select a more refined case, and employ as the exciting cause twenty or twenty-five vibrations per second, not of metal, but of air. Helmholtz found that, when vibrations of this kind, or, what is the same thing, when aërial waves, forty or fifty feet in length, were presented to the ear, the result was not sound, but an unbearable tickling sensation; as he shortened the waves, the effect altered gradually, until at last, when their length had been reduced to about thirty feet, he perceived a low, deep, musical note. If we undertook to extend his experiment, we should find that shortening the length of the wave raised the pitch of the note; that waves, five or six inches in length, furnished quite shrill notes; and that, finally, upon diminishing the wave-length to three or four tenths of an inch, the sound would become inaudible. It is quite certain that vast multitudes of still shorter waves exist, but we are deaf and blind to them; in us they excite no sensation. At this point there begins for us a great blank, in which, as Prof. Peirce once remarked, there is room for the play of not less than a dozen new senses, each as extensive as that of sight. Crossing, in imagination, this vast, unknown chasm, let us still pursue the shortening waves, and endeavor to trace their presence in a new region. We began with the heavy vibrations, the hammer-like strokes of a rod of metal, and exchanged them for the gentler aërial pulses, but now the air itself has become too coarse to transmit the far more delicate and minute waves which we next encounter: this is a feat which can only be accomplished by the all-pervading ether. Our new waves are very short; an army of ten thousand, marching in single file, would find room in an inch; but, though small, they are swift in motion: they will travel seven times around the earth in a second, and then be prepared for an interstellar journey. When they impinge on us, compensating for small size by vast number, they still produce a powerful sensation—we call it heat. Their effect upon the ear or eye is about the same as upon any other portion of the body; our ears are deaf, our eyes blind to them. But the state of the case alters when their length has been reduced to about the thirty-thousandth of an inch; they now become capable of acting on the eye, and with its aid we begin to perceive a faint red-brown color. Always shortening our wave-length, we find that the tint brightens into a pure red hue, changes

gradually into an orange tint, and, gaining greatly in luminosity, becomes pure yellow; passing thence by gradations into green and blue, it gently fades out in a violet and faint violet-gray or lavender. Beyond this point are yet more minute waves, but, in pursuing them, we enter once more what is for us a region of silence and darkness, and we are compelled to feel our way with the help of photographic plates.

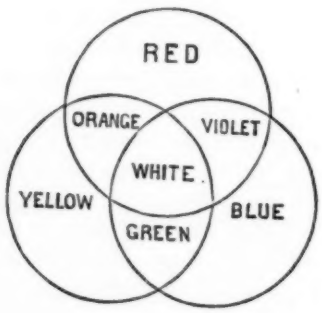
The series of tints just mentioned is now on the screen, and, were it worth while, the existence of systems of invisible waves upon either side could easily be demonstrated. The statements that I have made lead us, however, a little unexpectedly to a remarkable conclusion. They show that the beautiful colors now displayed have no existence outside of ourselves—that, outside of ourselves, there are merely waves, longer or shorter. Color is a sensation existing merely in ourselves. On the other hand, our eyes might have been made quite insensible to color while still preserving the power of vision, and it is not impossible for us to conceive the existence of beings to whom the luminous waves might only be what to us are the breakers on a sea-beach.

But, to resume: if we allow all these luminous waves to act simultaneously upon the eye, we obtain, not, as might perhaps be expected, a still richer and more gorgeous tint, but simply the sensation called white—brightness without color.

Now, it happens somewhat remarkably that all the color sensations I have mentioned, and all intermediate ones, can be approximately reproduced by the mixture in various proportions of merely three powders: when viewed by ordinary daylight one of the powders must be capable of reflecting red light, the others yellow and blue light respectively, that is to say, they must reflect abundantly the waves capable of producing these three sensations; the rest of the waves falling on them they must absorb and destroy, to a greater or less extent; or, finally, in common language, out of the mixture of red, yellow, and blue pigments, all the colors can be produced. This fact has been known for ages—it was old in the time of the Greeks, and probably dates back to that early period when the first serious attempts at painting were made by the human race. What could be more natural than that it should lead to the theory of the existence of only three *primary colors*, red, yellow, and blue, out of which all the others could be compounded: thus, orange out of a mixture of red and yellow, green by blue and yellow, and violet from red and blue. This theory was firmly established before Newton's time. During the present century it was the glory of one of England's greatest physicists that he had strengthened its foundations (it is found in most text-books on physics and art), and is to-day almost universally credited by painters. We have here upon the screen its well-known typical expression: three overlapping circles, the red one producing orange where it crosses

the yellow, and violet where it overlies the blue, the yellow and blue giving a bright green, while the central space, under the action of all the colors, is white (Fig. 1). As I said, the diagram now on the screen is the *typical* expression of the old theory, and is constructed so as to humor as much as possible the ideas of its supporters. If I had selected three pigments, and honestly worked the diagram out by their mixture, the result would have been much less brilliant and attractive.

FIG. 1.

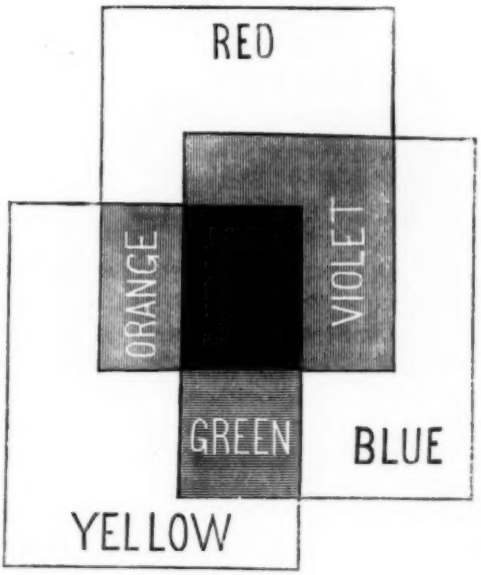


Let me make an actual experiment on this point: I throw upon the screen the image of three plates of stained glass; their colors are red, yellow, and blue; they are also rich and intense. These pieces are arranged so as to correspond to our three colored circles, and, in fact, where the blue crosses the yellow, a green hue is actually produced, but it is darker than either of its constituents; the violet is much darker than the red or blue, and, where all the plates cross at the centre, we have, instead of white light, complete darkness (Fig. 2). These peculiar strides in each case toward blackness would have been observed, if a corresponding experiment had been made with any three *pigments*, but this at present is a minor matter, and I leave it for the consideration of a vastly greater difficulty under which the old theory labors.

Let us inquire how the superimposed yellow and blue glasses came to produce green. The white light of the lantern contains all the different luminous waves, and it so happens that the yellow and blue glasses both agree mainly in transmitting only waves of a medium length, or, what is the same thing, green light. This can be proved by an examination with the spectroscope, which also reveals the fact that their agreement in this respect is by no means perfect, and that the green rays are also compelled to pay toll for their passage, though in a less proportion than the others. Exactly the same reasoning applies to blue and yellow pigments, and, from the effects produced by their mixture, it does not in the least follow that yellow and blue light make green light. This important point I now propose to test by what may be considered a fundamental experiment. For this pur-

pose, the superposition of the blue and yellow tints furnished by polarized light has lately sometimes been used, but, though the result obtained is quite correct, it may be objected that this experiment was perfectly well known to Sir David Brewster, the great modern defender of the old theory, as well as to all the physicists who were his followers; and this knowledge does not seem in the least, for more than a quarter of a century, to have weakened their confidence. Nor

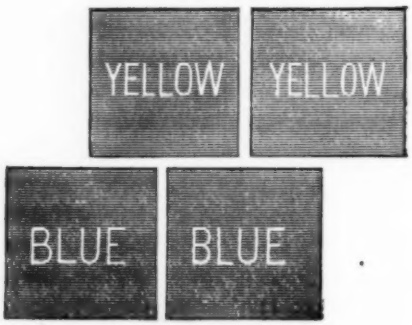
FIG. 2.



would it be perfectly satisfactory if I should bring about the union of blue and yellow light by the method of revolving colored disks, as is so often done; for, when we come to analyze this latter plan, we find that it consists, essentially, in presenting yellow and blue light to the eye, not simultaneously, but by a distinct succession of alternate acts. It is true that in this convenient mode of experimenting the results are the same as in that of simultaneous presentation, but just this point again would require proof, and, in a fundamental experiment like the present, ought not to be passed over in silence. To avoid these difficulties, I have contrived another plan, which will admit of our readily grasping the whole process, and inspecting its quite simple details. We have now upon the screen two large squares of blue light, and near them are two corresponding squares of yellow light (Fig. 3), and I can readily contrive matters so that the portion of the screen which is illuminated by one of the yellow squares shall also receive the light of a blue square. This we now have, and the result, as you see, is not the production of green light, or of light whose hue at all

approaches green; the light is *white*, with a slight tint of pink (Fig 4). Now, in this experiment, I have obtained our white light by the actual mixture on the screen of yellow and blue light, furnished by the *same* two glasses which, a little while ago, when superimposed,

FIG. 3.



gave us green light. The apparatus is so contrived that the glasses send toward the screen yellow and blue beams of light, but, before traveling far from the lantern, these beams are caught by this large crystal of cale-spar, and each, as you see, is duplicated. Let us pursue this matter a little further, and, to facilitate our judgment of the tints, I throw on the screen, near the colored squares, a circle of unaltered white light, for comparison. Perhaps we have failed to produce green light from the circumstance that our yellow squares were too bright; with a simple contrivance I can diminish their luminosity without altering their tint, and the rate of diminution you can easily watch in

FIG. 4.

the uncombined yellow square. This apparatus is now acting, but though under its influence the tint of the central square changes, passing from white by a series of gradations into blue, you see that it manifests no tendency to become green. Restoring the yellow squares to their original brightness, in the same way I gradually cut down the brightness of the blue squares, and yet fail to generate any hue approaching green.

A result like this ought to shake, if not entirely destroy, our confidence in the old theory, but Helmholtz has pursued the investigation still further, and has proved, in addition, that the union of the pure yel-

low and blue light of the spectrum itself furnishes not green but white light. There are also other points of almost equal importance where the old theory is at variance with the facts of Nature; some of them will be noticed further on, but, for the present, in summing up this matter, we may say that, while the old theory answers tolerably—only indifferently well for mixture of pigments on the painter's palette—it quite fails when applied with any exactitude to the explanation or study of effects of color in Nature.

SANITARY SCIENCE AND PUBLIC INSTRUCTION.[1]

By ANDREW D. WHITE, LL. D.,
PRESIDENT OF CORNELL UNIVERSITY.

YOU are well aware that it is not by virtue of any special claims as an investigator in sanitary science, or as a student in it to any great extent, that I now address you. But, when I was invited to speak, it seemed a good opportunity to make one more point in behalf of certain great, manly studies in our system of public instruction, and especially in our institutions for advanced instruction, and therefore an opportunity not to be neglected.

The generations that come after us will doubtless wonder at what this age has done, but I think they will wonder far more at what it has not done. There will be wonder at discoveries, inventions, reforms—at all our conquests in the realms of mind and matter; but I think the wonder will grow when notice is taken of the utter neglect, in great systems of education, of the most important subjects which occupy us, either for material purposes or for mental and moral advancement. Look, first, at the neglect of political studies. Here is a great Republic, dependent, as all confess, upon the knowledge of those who live beneath its sway. And yet you may go from one end of the country to the other and hardly find the slightest provision for any real instruction in Political Science, whether it be in political economy or political history. If, during the war of our rebellion, any thoughtful American wished to find out what that history was in which the germs of that great struggle were planted and developed, he had to go for such knowledge to the public lecture-room of Laboulaye at Paris, or the private lecture-room of Neumann at Berlin.

The case is still worse in regard to that great class of studies comprehended under the designation of Social Science. Every year our national Legislature and some forty State and Territorial Legislatures, and a vast number of county and town boards, are brought face to face with the most vital social problems. They are called upon to

[1] Read at the recent meeting of the American Public Health Association.

make great expenditures for the prevention and cure of pauperism, for the repression and punishment of crime, for the treatment of lunatics of various sorts, for the care of idiots of various grades, for the special treatment of inebriates, for the cure of the sick in hospitals, for general measures of prevention, as regards epidemics, and yet no one will gainsay my assertion that on no subject are our Legislature, and all our various public bodies, so utterly blind as on this. If we look at the result of this as regards expenditure, the case is bad enough. The amount annually expended in all our States for this purpose is enormous. The only approach which we have to the palaces of the Old World are in the various hospitals and prisons and asylums of the New. I can speak of this want of knowledge from personal experience. I can stand in the confessional on this subject. It has been my lot more than once to vote on such appropriations in a legislative body. I remember especially one case where the Legislature of this State was called upon to establish a great asylum, at vast expense, for a certain class of lunatics. The case was very pressing. A careful report from a commission showed that some provision of this sort must be made. A bill was passed, the buildings were erected, and yet, when all was done, we were assured by an expert, who had no interest one way or the other in the matter, that all our well-meant benevolence had, perhaps, resulted in almost as much evil as good, and that the whole institution was a failure as regards the immediate purposes for which it was erected. The simple cause for this was that in that whole Legislature, in the lower House, in the upper House, in the Executive Department, there was not one person who had ever given any close attention to subjects of this kind, and we had been obliged to trust entirely to those who could give us scraps of information, no matter how crude. But, if the immediate results are unfortunate, the remote results are still more so.

If any one wishes to see what vicious methods of dealing with great social questions will produce, he has only to look at the great harvest of evil which England is now reaping from seed sown 300 years ago, especially as regards the treatment of her pauper and criminal classes. I have said that there is no provision for thorough instruction. The reason is twofold. The first is the reluctance of educators to take up new subjects of study, or, at least, to present them thoroughly. But the other and far more effective reason is the fact that we have so few institutions for advanced education which have the means to make provision for such teaching. The last report of the Commissioners of Education at Washington shows that we have in this country about 400 establishments calling themselves colleges or universities. You may count on your fingers all those which really have any claim to either title. In obedience to the demands of sect or of locality, we have gone on multiplying institutions insufficiently endowed, wretchedly wanting in every thing necessary to scientific

investigation, until we have now hardly three or four in possession of the means to present any new subject of study involving any outlay for investigation or for demonstration. The time has come when such provision should be made. Whether it is to be made by the munificence of private individuals, or by State endowments, is not here the question.

The proposition to which I shall speak especially is this: that provision should be made for instruction in Human Physiology, Hygiene, and Sanitary Science, in all departments of public instruction in our public schools, by providing fundamental instruction, especially in the simple principles of physiology and hygiene; in colleges and universities, by presenting this general instruction in a more extended way, and by promoting investigation; in medical colleges, by giving more special instruction in matters relating to public and international hygiene; and that, in our departments of engineering and polytechnic and technological schools, especial provision should be made for instruction in sanitary engineering.

In regard to the first of these provisions, that for popular instruction, few probably are aware of the need of them. Take, for example, the revelation made within the past year, at the outbreak of yellow fever in a Southern city. Two things in relation to that revealed very clearly the evils of which I speak: First, the cause assigned to the disease shows the utter want of sanitary knowledge in the people at large; and, secondly, the real cause, since revealed, shows the absolute blindness to the simplest principles of sanitary science on the part of those immediately concerned. When the yellow fever broke out at Shreveport, it was telegraphed all over the country that it was caused by the removal of the obstructions in the river above the city. That statement went all over the country unchallenged. So far as I know, no one thought of expressing doubt publicly as to the statement that the yellow fever was caused by a more plentiful supply of water at the wharves of that city—the fact being that this would conduce rather to the removal of the causes of the disease than to the prevention of them. At last came information as to the real cause, and it was found that in that hot climate men had been allowed to heap up the material in which disease-germs arise abundantly; that the simplest truths of sanitary science had been ignored, and that the consequence was perfectly simple and natural.

But it is not merely in such outstanding parts of the nation that such ignorance exists. It is spread throughout our own country districts, even the most enlightened districts, and you will find prevailing in many of our country towns traditions and superstitions in regard to this matter that are most surprising. You will find some of these things which are known to be absolutely deadly considered on the whole as healthful. Strange as it may seem, you may hear people who take the papers, who are supposed to be within reach of the great

sources of information—you may hear such people, I say, maintaining that, after all, the emanations of the cesspool are rather conducive to health than to disease; that their fathers lived and throve in such an atmosphere, and that, therefore, it has a healthy influence. I can point you to an exceedingly pleasant village which I have sometimes to visit, where, with a plentiful supply of water, there is an absolute want of any system of sewerage. Typhoid and typhus go zigzag through that town every year or two, making victims, yet you can't induce the people of that village to believe that their unsewered condition has any thing to do with it.

But it is not merely in the country districts that this state of things has existed. Up to a very recent period at least this same ignorance was manifested in a very surprising degree in this metropolis. It is now about five years since, with two other members of our State Senate, I visited this city, and sat in the Commission for examining into certain branches of the city administration, and especially into the conduct of that branch which had the care of the public health. The state of things revealed was such as could only exist under a great and wide-spread ignorance on the part of citizens of the first principles of Sanitary Science. To give an idea of this ignorance, let me recall, as nearly as I can, a little episode in the investigation: It happened that the late Judge Whiting, who had charge of the investigation on the part of the Citizens' Association, put on the stand a young physician, who testified that the Health Officers, or Wardens, or Inspectors, were men utterly ignorant of the first principles relating to the public health which they were appointed to preserve. In order to refute this, the head of the Health Department at the time brought on the stand, in perfect good faith, several of these Health Officers. Toward the close of the examination of the first (one) of these gentlemen, Judge Whiting asked this question: "Did you have a case of small-pox in your ward?" and he answered, "Yes, sir." *Judge Whiting:* "Did you visit the patient?" *Witness:* "No, sir." *Judge Whiting:* "Why not?" *Witness:* "For the same reason that you would not; that I was afraid of taking it myself." *Judge Whiting:* "Did the family have any care?" *Witness:* "Yes, sir; they were 'highjinnicks' (hygienics); they doctored themselves." As the other witnesses came in, Judge Whiting used this as a sort of test question—as a sort of key to unlock the system, and show the utter ignorance that prevailed in every department of it. Every witness was asked: "Well, have you any 'highjinnicks' in your ward?" Some of the witnesses thought they had; some thought they had not; some thought they "had them pretty badly;" some thought they had them in some parts of the ward, some thought they had them in other parts of the ward. At last the Judge asked a witness, who had been answering his question in this way: "Do you know what the word 'highjinnicks' means?" and he replied: "Yes, sir, I do; it means a bad smell aris-

ing from dirty water." Of course the exhibition was vastly amusing, but, after all the guffaw was over, a sad after-thought necessarily came to every thinking man as to the condition of the great metropolis which allowed all its dearest material interests to be placed in such hands as this. It may be said that this was the result of a political system, but it was not. Had there been a tithe of the instruction which should have prevailed—of that simple knowledge that should have existed on this subject—such a thing would have been impossible, no matter what the political exigencies or arrangements were.

So much for the need of popular enlightenment on this subject. Look, now, at a higher range. It is only a few years since the country was startled by the outbreak of a malignant type of fever in one of the leading boarding-schools in New England. The result was, that several ladies from the most respectable families in the country lost their lives. The school had always been considered an admirable one. It was under the charge of a principal and instructors in every way worthy of their calling; but an investigation by competent persons showed that causes of zymotic disease lurked at every corner of the edifice, and that the only wonder was that the disease had not come earlier and spread even wider.

Look now at the want of special and technical instruction. It is little over ten years since the International Commission on Quarantine Matters sat in Paris. They did a great and noble work, but their labors have taken no such hold upon the policy of various States as they ought to have taken. What is the reason of this? There are admirable sanitarians in our own country and in others. We have several of whom the country may justly be proud; but the difficulty is, that our institutions have not given us enough of them to create and spread a healthy public opinion on this subject. One or two, or half a dozen, cannot, in so great a country as this, accomplish so great a work, and especially they cannot if they are burdened with the laborious duty of a metropolitan physician. There is a great want of special instruction in our medical colleges in public hygiene—hygiene in its relation to quarantine matters, in regard to the prevention of epidemics, in regard to sanitary provision for the wants of great cities and districts. Again, if you go into any of our interior States, you will find that any thing like a thorough or carefully-thought-out or wrought-out system of sewerage is a very rare exception to a very wide-spread rule. Nothing can be more inadequate than the system of sewerage of nine-tenths of our cities; and, indeed, until recently, the city of New York, with all its magnificent provision of water-supply, and in spite of its splendid position for drainage, was very improperly provided for in this respect. So much for the want of these different branches of instruction in this great science, and now as to the remedy which I would propose.

First, as regards Public Schools, I would make provision for simple

instruction in the elements of Physiology and Hygiene, either by the use of some short and plain text-book, or, what is still better, by lectures from some competent resident physician. I confess that I greatly prefer the latter method. Not only theory, but experience, leads me to prefer it. Were it not that we have made a very great mistake in our systems of public instruction, by severing our common-school instruction from advanced instruction, we should by this time have a body of teachers in our common schools abundantly able to lecture to the pupils without a text-book. I trust the time will come when provision will be made just as thoroughly for advanced instruction as for primary and common-school instruction, when all will be connected together; when the present illogical separation that exists, under which primary and common-school education is provided for by the State, and advanced education is left very inadequately provided by various religious denominations, will be done away with. But at present we have comparatively few teachers in our public schools who are competent, without text-books, to teach a subject of this kind; therefore it is that I would have provision made, in our larger schools especially, for lectures by resident physicians. That the interest of pupils can be roused in this way I know, for I have seen it fully tried. It is one of those subjects in which, with a little care, the great body of school-children can be greatly interested, and this without the slighest detriment to other subjects. The very change of method will make them come back to other subjects of study with renewed vigor.

Next, as to instruction in our Colleges and Universities. I would have instruction in physiology and hygiene more advanced, systematic, and thorough. Those who have read Herbert Spencer's work on "Education," no matter what they may think of some minor ideas, must have been greatly struck by that part in which he gives his estimate of the comparative value of different branches of knowledge. Among those which should be placed first he names Human Physiology. The reason is very simple. Human Physiology is simply the study of a machine which we are to run, nay, which is to run us for threescore years and ten. Certainly it is a study which falls very directly to us. The study of hygiene naturally comes in connection with it, and it was in obedience to this idea that, in framing the general course of instruction for the Cornell University, careful provision for physiology and hygiene was made. An extensive series of models was purchased, diagrams from Paris and London were obtained, and what was far better, a young professor, who had already begun to obtain a reputation not only as a close investigator, but as an impressive lecturer, was set at the work. The result has been most satisfactory. I am persuaded that study of this kind forms an admirable relief from other studies, pursued in a different way, and for a different purpose. In this case, the study of Physiology and Hygiene has been made very thorough. Frequent and close examinations have been demanded,

and it has been made not merely a study for information, but a study for discipline. And here let me say that, as a starting-point for scientific studies, the study of Hygiene and of Sanitary Science seems to me to have great value. It is not, perhaps, the best point theoretically from which to start, but practically it has been found to be as good as any other.

Next, as to instruction in our Medical Colleges, I speak here with great diffidence, for there are those about me more competent to discourse on this subject than I am. I am well aware that all the effective knowledge that is given to sanitary science in the country, so far as its advanced branches are concerned, is now given in the medical colleges. But it seems to me that not yet is sufficient place given for good instruction in Public Hygiene—sufficient study of that kind which gives to town authorities, county authorities, State authorities, the national authority, a body of experts who can be relied upon in various public emergencies, or, indeed, for ordinary care of public health.

Next, as to instruction in Departments of Engineering, and in our Scientific, Polytechnic, and Technological institutions. Within the past twenty-five years there has been created a science of Sanitary Engineering. I say within the past twenty-five years, although I know that engineering, even in ancient times, had frequent reference to sanitary considerations. Any one who has walked along the Tiber at Rome, as far as the mouth of the Cloaca Maxima, is well aware of that; but it is within the past twenty-five years that the science has been placed on solid foundations. Vital statistics have shown the effects of the introduction of sunlight, of pure water, and air, into our dwellings and cities, and engineering has shown us the best methods of introducing them. Any one who will take up the recent work on this subject by Mr. Baldwin Latham will see what great conquest has here been made. The statistics show that, of seven leading towns and districts in England, such as Croydon, Ely, Salisbury, and others, where careful and thorough modes of sewerage prevail, the percentage of deaths has been reduced from forty to twenty per cent. I also see, from calculations made on the basis of Dr. Allen's tables, that there is a saving to these districts pecuniarily. Taking into view the fact that, for every death prevented, about twenty cases of disease are prevented, I will say that, judged even from a cold financial point of view, the result has been magnificent. What the result would be by good modes of sanitary engineering may be judged from the statement in Dr. Lionel Beales's book on "Disease Germs," which is, that by a good system of sewerage 100,000 lives might be saved annually in England.

But I am aware of the opposition that will be made to any attempt to introduce these studies. First, it will be said that there is little material in this subject for advanced instruction, and that we know

very little regarding the causes or the nature of diseases. That is partly true and partly not true. Unquestionably, the true theory of disease is yet to be wrought out, although every thing leads us to suppose that science is at last upon the right track; but, unquestionably, in relation to the germ of disease, great conquests are yet to be made, and it is a matter of great satisfaction to me, and, I doubt not, to all of you, that one of the most careful of American investigators is to speak on that subject this evening.[1] So, too, the relations of ozone to various diseases is a matter in which conquests are still to be made. There are multitudes of questions yet to be solved, but still many have been solved already. And a very great conquest was made when it was found that zymotic diseases had relation to physical causes, and that the causes were ascertainable and removable. So, too, we have made conquests, as I have stated already, in sanitary engineering. There is material for study. We have made great advances in the study of vital statistics—there is another object of study. I think that this objection, feeble as it is at present, should rapidly become more feeble as science advances, and it can have but little weight among thoughtful men.

But there is another class of objections which are more constantly made—the same objections that have been made to every change in the curriculum of study, from the days of Erasmus until now, and to any liberty in the choice of studies. Those objections are on the score of Discipline and Culture. I remember once that, when this objection was made in the presence of the late Horace Greeley, he cried out, "Discipline! I hate the word." Nor was this exclamation unnatural. Few words have done more harm to the progress of education than this. I am the last to say any thing against what is now known as the older system of education, or of classical education in general. I prize it; I love it; but, if there were no other argument to show that it is by no means the only mode of discipline or study, the return made by the Commissioners of the English Government, after their examination of the English public schools, is certainly proof on this point. It is there shown that seventy per cent. of the students under the old system, carried out as it is to its very highest point, failed to make any worthy use of their advantage.

What are disciplinary studies? I maintain simply that they are those which for any reason whatever a man takes hold of, and which take hold of him. It matters not whether the study be in obedience to natural tastes, or whether it be forced upon the student. This is the thing—that the study be taken hold of, and that it take hold of the mind of the person studying. Now, in our primary instruction, the studies which I here advocate take hold of great numbers of pupils; take hold of them by virtue of their being a relief from other

[1] President Barnard, of Columbia College, presented a paper on "The Germ Theory of Disease in its Relations to Hygiene."

studies—by virtue of their appealing to natural objects. Any teacher will bear me out in saying that, as regards pupils of an early age, there is no difficulty in this respect. As regards colleges and universities, there are but two things on which we can rely to make studies take hold upon the minds of students, and to receive thorough attention. The first is, love for them on the part of the student. The other is, their value to the student as regards his direct aims and purposes in life. We cannot in colleges and universities do what was formerly done in England—take the student and whip him. We have to trust to one or the other of these two classes of incentives. Now, the number is considerable of those who, from one motive or the other, would take up this great subject of study. All would not do it; the majority, probably, would not do it; but, if an opportunity were offered, I am satisfied that from every college and every university would go out a body of men not only well instructed in the great principles which underlie sanitary matters, but well disciplined in the obtaining of such instruction.

And now, as to the other branch of the objection—the objection on the score of Culture.

I prize all literary study as highly as any person ought, but yet I maintain that there is, after all, a higher culture. The very ideal, the very god of literary culture, is Goethe; and yet, splendid as he was, there is a higher culture which he lacked, even from a purely earthly point of view. I maintain that, in the studies I now urge, there comes a culture of high purpose, a culture of thought for our fellow-men, a culture involving the idea of duty, which certainly is worth any other sort of culture.

And, if any one objects that these studies are based upon Physiology, which has led man into dangerous paths, that it is, in fact, an unsafe study, I would simply point to these words, uttered so long ago, and from which, certainly, these objectors will make no appeal: "The fear of the Lord is the beginning of wisdom." There is a great truth in these words. We all feel them. But what is that truth? what is that fear? Is it the mere selfish fear which the African native feels for the madness of his fetish? Is it the mere groveling fear which the Turkish slave feels for the tyranny of the satrap placed over him? Certainly not. The only wholesome fear is that fear based not on mystic dread of tyranny, but fear to violate those great laws by which the Divine power which maintains and regulates this universe governs all. That is the fear which lies at the beginning of wisdom, and among those studies, calculated to impress upon us the existence of laws, the violation of which is followed by penalties strictly imposed, stand foremost those to which this Association is now so worthily devoting its attention—studies sure to make the earth more beautiful; sure to make mankind more reverent and noble.

THE DISSIPATION OF ENERGY.[1]

By H. F. WALLING.

THE dissipation of energy is a continuous process, quite familiar to mankind in its main features and results, since the days of the ancient philosophers. It was recognized by them that all mechanical motions, being dissipated by friction, gradually diminish, and must finally cease unless maintained by external power. In the language of modern science, the motion which thus disappears is converted from molar into molecular motion.

It may be added that molecular energy, existing mainly in the form called heat, tends to equalization of dynamic equilibrium, after the attainment of which it is powerless to produce molar or mechanical motion, a reconversion from the condition of equilibrium being impossible.

Accordingly, the power to produce mechanical motion, exerted by the heat of the sun, which is being lavished with such prodigious prodigality, can only last while the sun continues to be hotter than the other bodies in space. At present it is well understood that all terrestrial motive power is derived from this source with the single unimportant exception of that obtained from the tides, at the expense of the earth's energy of rotation. Among the more obvious processes of conversion of the sun's molecular into terrestrial molar motion, are the expansion and contraction of the atmosphere, the evaporation and condensation of water, and the less direct method by restoration of potential chemical energy accomplished in vegetation, whence are produced food and fuel.

But it is supposed that the sun will finally grow cold, and that the resistance of the ethereal medium, the evidence of whose existence is found in the demonstration of the undulatory theory of light, will cause satellites to fall into planets, planets into suns, and suns into one common centre, after which, unless by special interposition of divine power, darkness, silence, and death, will forever prevail.

This gloomy prediction is of course inconsistent with the theory of continuous evolution, which obviously excludes from cosmical economy catastrophes or extensive destructive effects.

A careful consideration, however, of the circumstances which will be likely to accompany the falling of a satellite into its planet may lead to the conclusion that this occurrence will not necessarily be catastrophic. The process must certainly be an exceedingly *slow* one, no progress in it having been detected throughout all the recorded observations of the moon's motion extending over thousands of years.

[1] The Relation of the Dissipation of Energy to Cosmical Evolution. Read at the Portland meeting of the American Association for the Advancement of Science.

The only practical evidence which has been adduced to prove the resistance of a medium, namely, a very slight diminution in the period of that nearly evanescent body, Encke's Comet, is very far from being definite and satisfactory. The mass of the moon being enormously greater, it is probable that many millions of years will pass before a diminution of her orbital period from this cause will be perceptible. The immense periods of time attributed to the past processes of geological evolution, and to the supposed metamorphoses of organic life, are therefore very brief when compared with those required for the returns of satellites to their parent orbs, admitting, as theoretical considerations seem to require, that such returns are ultimately inevitable.

The eccentricity being diminished by the resistance of a medium, the moon's orbit would eventually become, and afterward continue, circular, so that final contact would be unaccompanied by violent collision. But, before the time of actual contact, changes of form would be induced both in planet and satellite by mutual attractions, exemplified in the production of daily terrestrial *tides*. The investigations of Hopkins, Thomson, and recently of Barnard, in regard to tidal and precessional influences, indicate that, even at the present distance of the moon, they must cause elongations and contractions of the solid materials of the earth, which are quite appreciable. A considerable diminution of the distance between the earth and moon would give rise to changes in the form of the earth, and hence to bendings to and fro of its external shell even if the earth were solid throughout. This would be accompanied by earthquakes and kindred disturbances far exceeding in magnitude and destructiveness any thing of the kind now known to man. The frequency of these occurrences would be the same as that of the moon's meridian passage.

Resistances to this tidal action, however, would be developed, in consequence of which the molar motion of rotation would be converted into molecular motion, so long as the angular motion of rotation in either body was different from that of the moon's revolution, until the rotations became synchronous with the revolution, a condition already arrived at in the case of the moon. Synchronism once attained would be permanent, acceleration both of revolution and rotation occurring as the distance diminished, and both at the expense of the potential energy of gravity between the two bodies. Each body presenting the same face to the other, no meridian passage could take place, and hence no tidal action.

But there yet remains to be considered a continually increasing tendency to distortion of form consequent upon approach. This effect would be produced very gradually, being spread over such enormous durations of time. The curious and complicated foldings of the rocks in the Appalachian regions indicate that the solid materials of the earth are sufficiently plastic to allow it to take on any form toward which forces of sufficient magnitude direct it, provided the times be

very greatly extended. Hence, considering the extreme slowness of the process, it may be reasonable to conclude that the forms ultimately developed would be identical with those which would be assumed by liquid masses having the same relative positions and velocities.

The determination of these forms is a problem for the mathematicians. In the absence of analysis, no reason is manifest for supposing that the forms of equilibrium would be materially different just before and just after contact. May it not be that the order of change would be a partial reversal of certain supposed processes of the nebular hypothesis? Thus the moon may be gradually elongated into a closed ring which will slowly contract upon the earth as the energy of angular velocity is gradually dissipated by the friction of the medium. In any event there seems to be no good reason to suppose that there will be such a sudden leap in the final osculation or embrace as would result in a catastrophe.

The same considerations apply to the gravitational relations between planets and suns. Other very important relations between these bodies, however, with which organic life is more especially concerned, require attention. One fundamental requisite to all known terrestrial organic life is the conversion, within living bodies, of molecular energy, either into molar motions, or into potential energy which may afterward be thus converted. All living animals and plants, therefore, depend for their existence upon the passage through their bodies, in the movement toward distribution and equalization, of heat, light, and other molecular forces originating in the sun.

The integrity of cosmical evolution in relation to organic life, accordingly, seems to require the maintenance of great central laboratories where molecular disturbances of sufficient intensity and quantity can be continually generated, and their effects distributed throughout the universe. Notwithstanding the enormous expenditure of heat by the sun, its temperature is supposed to have been maintained about the same as at present for a very long period of time in the past, and no reason is manifest why this fixed temperature will not continue for a very long time in the future. Doubtless, operations are going on in the sun which it would be impossible to imitate in terrestrial laboratories. May it not be that the conditions of materials and the circumstances of pressure, chemical affinity, etc., are such, that substances more elementary than our so-called chemical elements are uniting with an energy far exceeding that of any chemical combination we can effect, and so prodigious as to maintain, at comparatively small expenditure of material, the sun's temperature at that enormous degree which marks the *dissociation* point of the tremendously energetic combination? The duration of the combination or combustion would thus be prolonged to an enormously remote period. At last, when all the potential energy due to this particular reaction became exhausted by the combination of all

the special materials required for it, new materials, whose dissociation point had a lower temperature, and which had consequently been prevented from combining previously, would commence upon a similar process of combustion. And so we may suppose combination to follow combination, until, finally, perhaps at a time when the planets, freighted with their living inhabitants, have begun to arrive at the sun's surface, long after the fires of the last combustion have expired, it has itself become a habitable globe, lighted and heated or served by other molecular forces from distant orbs where new conditions cause new chemical combinations, and conversions of newly-developed potential energies.

Finally, giving play to the imagination, may we not suppose further, that, in a universe extended throughout infinite space, processes of concentration similar to those supposed in the nebular hypothesis and supplemented by processes like those here indicated will go on forever, evolving worlds of continually-increasing magnificence, perhaps inhabited by living occupants of inconceivably transcendent and ever-expanding faculties?

NEWS FROM JUPITER.

By RICHARD A. PROCTOR, B.A.

THE planet Jupiter has passed during the last year through a singular process of change. The planet has not, indeed, assumed a new appearance, but has gradually resumed its normal aspect after three or four years, during which the mid zone of Jupiter has been aglow with a peculiar ruddy light. The zone is now of a creamy-white color, its ordinary hue. We have, in fact, reached the close of a period of disturbance, and have received a definite answer to questions which had arisen as to the reality of the change described by observers. Many astronomers of repute were disposed to believe that the peculiarities recently observed were merely due to the instruments with which the planet has been observed—not, indeed, to any fault in those instruments, but, in fact, to their good qualities in showing color. A considerable number of the earlier accounts of Jupiter's change of aspect came from observers who used the comparatively modern form of telescope known as the silvered-glass reflectors, and it is well known that these instruments are particularly well suited for the study of color-changes. Nevertheless, observations made with the ordinary refracting telescope were not wanting; and it had begun to be recognized that Jupiter really had altered remarkably in appearance, even before that gradual process of change which, by restoring his usual aspect, enabled every telescopist to assure himself that there had been no illusion in the earlier observations.

I propose now to discuss certain considerations which appear to me to indicate the nature and probable meaning of the phenomena which have recently been observed in Jupiter. It seems to me that these phenomena are full of interest, whether considered in themselves or in connection with those circumstances on which I had been led to base the theory that Jupiter is a planet altogether unlike our earth in condition, and certainly unfit to be the abode of living creatures.

I would first direct special attention to the facts which have been ascertained respecting the atmosphere of Jupiter.

It does not appear to have been noticed as a remarkable circumstance, that Jupiter should have an atmosphere recognizable from our distant station. Yet, in reality, this circumstance is not only most remarkable, but is positively inexplicable on any theory by which Jupiter is regarded as a world resembling our own. It is certain that, except by the effects produced when clouds form and dissipate, our terrestrial atmosphere could not be recognized at Jupiter's distance with any telescopic power yet applied. But no one who has studied Jupiter with adequate means can for a moment fail to recognize the fact that the signs of an atmosphere indicate much more than the mere formation and dissipation of clouds. I speak here after a careful study of the planet during the late opposition, with a very fine reflecting telescope by Browning, very generously placed at my disposal by Lord Lindsay; and I feel satisfied that no one can study Jupiter for many hours (on a single night) without becoming convinced that the cloud-masses seen on his disk have a *depth* comparable with their length and breadth. Now, the depth of terrestrial cloud-masses would at Jupiter's distance be an absolutely evanescent quantity. The span of his disk represents about 84,000 miles, and his satellites, which look little more than points in ordinary telescopes, are all more than 2,000 miles in diameter. I am satisfied that any one who has carefully studied the behavior of Jupiter's cloud-belts will find it difficult to believe that their depth is less than the twentieth part of the diameter of the least satellite. Conceive, however, what the depth of an atmosphere would be in which cloud-masses a hundred miles deep were floating!

It may be asked, however, in what sense such an atmosphere would be inexplicable, or, at least irreconcilable with the theory that Jupiter is a world like our earth. Such an atmosphere would be in strict proportion, it might be urged, to the giant bulk of the planet, and such relative agreement seems more natural than would be a perfect correspondence between the depth of the atmosphere on Jupiter and the depth of our earth's atmosphere.

But it must not be forgotten that the atmosphere of Jupiter is attracted by the mass of the planet; and some rather remarkable consequences follow when we pay attention to this consideration. Of course a great deal must be assumed in an inquiry of the sort. Since, however, we are discussing the question whether there can be any re-

semblance between Jupiter and our earth, we may safely (so far as our inquiry is concerned) proceed on the assumption that the atmosphere of Jupiter does not differ greatly in constitution from that of our earth. We may further assume that, at the upper part of the cloud-layers we see, the atmospheric pressure is not inferior to that of our atmosphere at a height of seven miles above the sea-level, or one-fourth of the pressure at our sea-level. Combining these assumptions with the conclusion just mentioned, that the cloud-layers are at least 100 miles in depth, we are led to the following singular result as to the pressure of the Jovian atmosphere at the bottom of the cloud-layer: The atmosphere of any planet doubles in pressure with descent through equal distances, these distances depending on the power of gravity at the planet's surface. In the case of our earth, the pressure is doubled with descent through about $3\frac{1}{2}$ miles; but gravity on Jupiter is more than $2\frac{1}{2}$ times as great as gravity on our earth, and descent through $1\frac{2}{5}$ mile would double the pressure in the case of a Jovian atmosphere. Now, 100 miles contain this distance ($1\frac{2}{5}$ mile) more than seventy-one times; and we must therefore double the pressure at the upper part of the cloud-layer seventy-one successive times to obtain the pressure at the lower part. Two doublings raise the pressure to that at our sea-level; and the remaining sixty-nine doublings would result in a pressure exceeding that at our sea-level so many times that the number representing the proportion contains twenty-one figures.[1] I say *would* result in such a pressure, because in reality there are limits beyond which atmospheric pressure cannot be increased without changing the compressed air into the liquid form. What those limits are we do not know, for no pressure yet applied has changed common air, or either of its chief constituent gases, into the liquid form, or even produced any trace of a tendency to assume that form. But it is easily shown that there must be a limit to the increase of pressure which air will sustain without liquefying. For the density of any gas changes proportionately to the increase of pressure until the gas is approaching the state when it is about to turn liquid. Now, air at the sea-level has a density equal to less than the 900th part of the density of water; so that, if the pressure at the sea-level were increased 900 times, either the density would not increase proportionally, which would show that the gas was approaching the density of liquefaction, *or else* the gas would be denser than water, which must be regarded as utterly impos-

[1] The problem is like the well-known one relating to the price of a horse, where one farthing was to be paid for the first nail of 24 in the shoes, a half-penny for the next, a penny for the third, two pence for the fourth, and so on. It may be interesting to some of my readers to learn, that if we want to know roughly the proportion in which the first number is increased by any given number of doublings, we have only to multiply the number of doublings by $\frac{3}{10}$ths, and add 1 to the integral part of the result, to give the number of digits in the number representing the required proportions. Thus multiplying 24 by $\frac{3}{10}$ths gives 7 (neglecting fractions); and therefore the number of farthings in the horse problem is represented by an array of 8 digits.

sible. Or, if any one is disposed, for the sake of argument, to assume that a gas (*at ordinary temperatures*) may be as dense as water, then we need proceed but a few steps further, increasing the pressure about 18,000 times instead of 900 times, to have the density of *platinum* instead of that of water, and no one is likely to maintain that our air could exist in the gaseous form with a density equaling that of the densest of the elements. We are still an enormous way behind the number of twenty-one figures mentioned above; and, in fact, if we supposed the pressure and density to increase continually to the extent implied by the number of twenty-one figures, we should have a density exceeding that of platinum more than ten thousand millions of millions of times!

Of course this supposition is utterly monstrous, and I have merely indicated it to show how difficulties crowd around us in any attempt to show that a resemblance exists between the condition of Jupiter and that of our earth. The assumptions I made were sufficiently moderate, be it noticed, since I simply regarded (1) the air of Jupiter as composed like our own; (2) the pressure at the upper part of his cloud-layer as not less than the pressure far above the highest of our terrestrial cumulus clouds (with which alone the clouds of Jupiter are comparable); and (3) the depth of his cloud-layer as about one hundred miles. The first two assumptions cannot fairly be departed from to any considerable extent, without adopting the conclusion that the atmosphere of Jupiter is quite unlike that of our earth, which is precisely what I desire to maintain. The third is, of course, open to attack, though I apprehend that no one who has observed Jupiter with a good telescope will question its justice. But it is not at all essential to the argument that the assumed depth of the Jovian atmosphere should be even nearly so great. We do not need a third of our array of twenty-one figures, or even a seventh part, since no one who has studied the experimental researches made into the condition of gases and vapors can for a moment suppose that an atmosphere like ours could remain gaseous, *except at an enormously high temperature*, at a pressure of two or three hundred atmospheres. Such a pressure would be attained, retaining our first two assumptions, at a depth of about fourteen miles below the upper part of the cloud-layer. This is about the six-thousandth part of the diameter of Jupiter; and, if any student of astronomy can believe that that wonderfully complex and changeful cloud-envelope which surrounds Jupiter has a thickness of less than the six-thousandth part of the planet's diameter, I would recommend as a corrective the careful study of the planet for an hour or two with a powerful telescope, combined with the consideration that the thickness of a spider's web across the telescopic field of view would suffice to hide a breadth of twenty miles on Jupiter's disk.

But we are not by any means limited to the reasoning here indicated, convincing as that reasoning should be to all who have studied

the aspect of Jupiter with adequate telescopic power. We have in Jupiter's mean density an argument of irresistible force against the only view which enables us even hypothetically to escape from the conclusions just indicated. Let it be granted, for the sake of argument, that Jupiter's cloud-layer is *less* than fourteen miles in depth, so that we are freed for the moment from the inference that at the lower part of the atmosphere there is either an intense heat or else a density and pressure incompatible with the gaseous condition. We cannot, in this case, strike off more than twenty-eight miles from the planet's apparent diameter to obtain the real diameter of his solid globe—solid, at least, if we are to maintain the theory of his resemblance to our earth. This leaves his real diameter appreciably the same as his apparent diameter, and as a result we have the mean density of his solid globe equal to a fourth of the earth's mean density, precisely as when we leave his atmosphere out of the question. Now, I apprehend that the time has long since passed when we can seriously proceed at this stage to say, as it was the fashion to say in text-books of astronomy, "Therefore the substance of which Jupiter is composed must be of less specific gravity than oak and other heavy woods." We know that Brewster gravely reasoned that the solid materials of Jupiter might be of the nature of pumice-stone, so that, with oceans resembling ours, a certain latitude was allowed for increase of density in Jupiter's interior. But, in the presence of the teachings of spectroscopic analysis, few would now care to maintain, as probable, so preposterous a theory as this. Every thing that has hitherto been learned, respecting the constitution of the heavenly bodies, renders it quite unlikely that the elementary constitution of Jupiter differs from that of our earth. Again, it was formerly customary to speak of the possibility that Jupiter and Saturn might be hollow globes, mere shells, composed of materials as heavy as terrestrial elements. But, whatever opinion we may form as to the possibility that a great intensity of heat may vaporize a portion of Jupiter's interior, we know quite certainly that there must be enormous pressure throughout the whole of the planet's globe, and that even a vaporous nucleus would be of great density. For it is to be remembered that all that I have said above respecting the possibility of gases existing at great pressures applies only to ordinary temperatures—such temperatures, for example, as living creatures can endure. At exceedingly high temperatures much greater pressure, and therefore much greater density, can be attained without liquefaction or solidification. And, in considering the effect of pressure on the materials of a solid globe, we must not fall into the mistake of supposing that the strength of such solid materials can protect the material from compression and its effects. We must extend our conceptions beyond what is familiar to us. We know that any ordinary mass of some strong, heavy solid—as iron, copper, or gold—is not affected by its own weight so as to change in structure to

an appreciable extent. The substance of a mass of iron forty or fifty feet high, would be the same in structure at the bottom as at the top of the mass; for the strength of the metal would resist any change which the weight of the mass would (otherwise) tend to produce. But if there were a cubical mountain of iron twenty miles high, the lower part would be absolutely plastic under the pressure to which it would be subjected. It would behave in all respects as a fluid, insomuch that if (for convenience of illustration) we suppose it inclosed within walls made of some imaginary (and impossible) substance which would yield to no pressure, then, if a portion of the wall were removed near the base of the iron mountain, the iron would flow out like water [1] from a hole near the bottom of a cask. The iron would continue to run out in this way, until the mass was reduced several miles in height. In Jupiter's case a mountain of iron of much less height would be similarly plastic in its lower parts, simply because of the much greater attractive power of Jupiter's mass. Thus we see that the conception of a hollow interior, or of any hollow spaces throughout the planet's globe, is altogether inconsistent with what is known of the constitution of even the strongest materials.

How, then, are we to explain the relatively small mean density of Jupiter's globe? On the supposition that his atmosphere is less than fourteen miles deep, we cannot do so; for there is nothing hypothetical in the above considerations respecting a solid globe as large as Jupiter's, excepting always the assumption that the globe is not formed of substances unlike any with which we are familiar. Even this assumption, though it is one which few would care to maintain in the present position of our knowledge, amounts after all to an admission of the chief point which I am endeavoring to maintain: itis one way—but a very fanciful way—of inferring that Jupiter is utterly dissimilar to the earth. Rejecting it, as we safely may, we find the small density of Jupiter not merely unexplained, but manifestly inexplicable.

All our reasoning has been based on the assumption that the atmosphere of Jupiter exists at a temperature not greatly differing from that of our own atmosphere. If we assume instead an exceedingly high temperature, abandoning of course the supposition that Jupiter is an inhabited world, we no longer find any circumstances which are self-contradictory or incredible.

To begin with, we may on such an assumption find at once a parallel to Jupiter's case in that of the sun. For the sun is an orb attracting his atmospheric envelope and the material of his own solid or liquid surface (if he has any) far more mightily than Jupiter has been known to do. All the difficulties considered in the case of Jupiter would be enormously enhanced in the case of the sun, if we forgot the fact that the sun's globe is at an intense heat from surface to cen-

[1] The effect of pressure in rendering iron and other metals plastic has been experimentally determined. Cast-steel has been made to flow almost like water, under pressure.

tre. Now, we know that the sun is intensely hot because we feel the heat that he emits, and recognize the intense lustre of his photosphere; so that we are not in danger of overlooking this important circumstance in his condition. Jupiter gives out no heat that we can feel, and assuredly Jupiter does not emit an intense light of his own. But, when we find that difficulties, precisely corresponding in kind, though not in degree, to those which we should encounter if we discussed the sun's condition in forgetfulness of his intense heat, exist also in the case of Jupiter, it appears manifest that we may safely adopt the conclusion that Jupiter is intensely heated, though not nearly to the same degree as the sun.

We have thus been led by a perfectly distinct an independent line of reasoning to the very conclusion which I have advocated elsewhere on other grounds, viz., that Jupiter is in fact a miniature sun as respects heat, though emitting but a relatively small proportion of light. I would invite special attention to the circumstance that the evidence on which this conclusion had been based was already cumulative. And now a fresh line of evidence, in itself demonstrative I conceive, has been adduced. Moreover, I have not availed myself of the argument, very weighty in my opinion, on which Mr. Mattieu Williams has based similar conclusions respecting the temperature of Jupiter, in his interesting and valuable work called "The Fuel of the Sun." I fully agree with him in regarding it as a reasonable assumption, though I cannot go so far as to regard it as certain, that every planet has an atmosphere whose mass corresponds with, or is even perhaps actually proportional to, the mass of the planet it surrounds. If we make such an assumption in the case of Jupiter, we arrive at conclusions closely resembling those to which I have been led by the above process of reasoning.

Thus many lines of evidence, and some of them absolutely demonstrative, in my opinion, point to the conclusion that Jupiter is an orb instinct with fiery energy, aglow it may well be with an intense light which is only prevented from manifesting itself by the cloudy envelope which enshrouds the planet.

But, so soon as we regard the actual phenomena presented by Jupiter in the light of this hypothesis, we find the means of readily interpreting what otherwise would appear most perplexing. Chief among the phenomena thus accounted for, I would place the recent color-changes in the equatorial zone of Jupiter.

What, at a first view, could appear more surprising than a change affecting the color of a zone-shaped region whose surface is many times greater than the whole surface of our earth. It is true that a brief change might be readily explained as due to such changes as occur in our own air. Large regions of the earth are at one time cloud-covered, and at another free from clouds. Such regions, seen from Venus or Mercury, would at one time appear white, and at the other would

show whatever color the actual surface of the ground might possess when viewed as a whole. But it seems altogether impossible to explain in this way a change or series of changes occupying many years, as in the case of the recent color-changes of Jupiter's belt. Let me not be misunderstood. I am not urging that the changes in Jupiter are *not* due to the formation and dissipation of clouds in his atmosphere. On the contrary, I believe that they are. What seems to me incredible is, the supposition that we have here to deal with such changes as occur in our own air in consequence of solar action.

I do not lose sight of the fact that the Jovian year is of long duration, and that whatever changes take place in the atmosphere of Jupiter through solar action might be expected to be exceedingly slow. Nay, it is one of the strongest arguments against the theory that solar action is chiefly in question, that any solar changes would be so slight as to be in effect scarcely perceptible. It is not commonly insisted upon in our text-books of astronomy—in fact, I have never seen the point properly noticed anywhere—that the seasonal changes in Jupiter correspond to no greater *relative* change than occurs in our daily supply of solar heat from about eight days before to about eight days after the spring or autumn equinox. It is incredible that so slight an effect as this should produce those amazing changes in the condition of the Jovian atmosphere which have unquestionably been indicated by the varying aspect of the equatorial zone. It is manifest that, on the one hand, the seasonal changes should be slow and slight so far as they depend on the sun, and, on the other, that the sun cannot rule so absolutely over the Jovian atmosphere as to cause any particular atmospheric condition to prevail unchanged for years.

If, however, Jupiter's whole mass is in a state of intense heat—if the heat is in fact sufficient, as it must be, to maintain an effective resistance against the tremendous force of Jovian gravitation—we can understand any changes, however amazing. We can see how enormous quantities of vapor must continually be generated in the lower regions to be condensed in the upper regions, either directly above the zone in which they were generated, or north or south of it, according to the prevailing motions in the Jovian atmosphere. And, although we may not be able to indicate the precise reason why at one time the mid zone or any other belt of Jupiter's surface should exhibit that whiteness which indicates the presence of clouds, and at another should show a coloring which appears to indicate that the glowing mass below is partly disclosed, we remember that the difficulty corresponds in character to that which is presented by the phenomena of solar spots. We cannot tell why sun-spots should wax and wane in frequency during a period of about eleven years; but this does not prevent us from adopting such opinions as to the condition of the sun's glowing photosphere as are suggested by the behavior of the spots.

It may be asked whether I regard the ruddy glow of Jupiter's equatorial zone, during the period of disturbance lately passed through, as due to the inherent light of glowing matter underneath his deep and cloud-laden atmosphere. This appears to me on the whole the most probable hypothesis, though it is by no means certain that the ruddy color may not be due to the actual constitution of the planet's vaporous atmosphere. In either case, be it noted, we should perceive in this ruddy light the inherent lustre of Jupiter's glowing mass, only in one case we assume that that lustre is itself ruddy, in the other we suppose that light, originally white, shines through ruddy vapor-masses. It is to be remembered, however, that, whichever view we adopt, we must assume that a considerable portion of the light received, even from these portions of the planet's disk, must have been reflected sunlight. In fact, from what we know about the actual quantity of light received from Jupiter, we may be quite certain that no very large portion of that light is inherent. Jupiter shines about as brightly as if he were a giant cumulus-cloud, and therefore almost as white as driven snow. Thus he sends us much more light than a globe of equal size of sandstone, or granite, or any known kind of earth. We get from him about three times as much light as a globe like our moon in substance, but as large as Jupiter, and placed where Jupiter is, would reflect toward the earth; but not quite so much as we should receive from a globe of pure snow of the same size and similarly placed. It is only because large parts of the surface of Jupiter are manifestly *not* white, that we seem compelled to assume that some portion of his light is inherent. But the theory that Jupiter is intensely hot by no means requires, as some mistakenly imagine, that he should give out a large proportion of light. His real solid or liquid globe (if he have any) might, for instance, be at a white heat, and yet so completely cloud-enwrapped that none of its light could reach us. Or, again, his real surface might be like red-hot iron, giving out much heat but very little light.

I shall close the present statement of evidence in favor of what I begin to regard as in effect a demonstrated theory, with the account of certain appearances which have been presented by Jupiter's fourth satellite during recent transits across the face of the planet. The appearances referred to have been observed by several telescopists, but I will select an account given in the monthly notices of the Astronomical Society, by Mr. Roberts, F.R.A.S., who observed the planet with a fine telescope by Wray, eight inches in aperture. "On March 26, 1873," he says, "I observed Jupiter about 8 P.M., and found the fourth satellite on the disk. I thought at first it must be a shadow; but, on referring to the *Nautical Almanac*, found that it was the fourth satellite itself. A friend was observing with me, and we both agreed that it was a very intense black, and also was not quite round. We each made independent drawings, which agreed perfectly, and consider that the observation was a perfectly reliable one. We could

not imagine that such an intensely black object would be visible when off the disk, and waited with some impatience to see the emersion, but were disappointed by fog, which came on just at the critical time." Another observer, using a telescope only two inches in aperture, saw the satellite when off the disk, so that manifestly the blackness was merely an effect of contrast.

In considering this remarkable phenomenon, we must not forget that the other satellites do not look black (though some of them look dark) when crossing Jupiter's disk, so that we have to deal with a circumstance peculiar to the fourth or outermost satellite. Nevertheless, we seem precluded from supposing that any other difference exists between this satellite and the others than a certain inferiority of light-reflecting power. I might indeed find an argument for the view which I have suggested as not improbable, that Jupiter is a heat-sun to his satellites, since the three innermost would be in that case much better warmed than the outermost, and therefore would be much more likely to be cloud-encompassed, and so would reflect more light. But I place no great reliance on reasoning so ingenious, which stands much as a pyramid would stand (theoretically) on its apex. The broad fact that a body like the fourth satellite, probably comparable to our moon in light-reflecting power, looks perfectly black when on the middle of Jupiter's disk, is that on which I place reliance. This manifestly indicates a remarkable difference between the brightness of Jupiter and the satellite; and it is clear that the excess of Jupiter's brightness is in accordance with the theory that he shines in part with native light, or, in other words, is intensely heated.

This completes the statement of the evidence obtained during the recent opposition of Jupiter in favor of a theory which already had the great advantage of according with all known facts, and accounting for some which had hitherto seemed inexplicable. If this theory removes Jupiter from the position assigned to him by Brewster as the noblest of inhabited worlds, it indicates for him a higher position as a subordinate sun, nourishing with his heat, as he sways by his attractive energy, the scheme of worlds which circles round him. The theory removes also the difficulty suggested by the apparent uselessness of the Jovian satellites in the scheme of creation. When, instead of considering their small power of supplying Jupiter with light, we consider the power which, owing to his great size and proximity, he must possess of illuminating them with reflected light, and warming them with his native heat, we find a harmony and beauty in the Jovian system which before had been wanting; nor, when we consider the office which the sun subserves toward the members of his family, need we reject this view on account of the supposition—

> "That bodies bright and greater should not serve
> The less not bright."

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THE SPANG COLLECTION OF MINERALS.

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THE increasing taste for the pursuit of natural science in this country is strikingly exhibited by the rapid increase in the number of gem and mineral collections. The taste is not confined to men of any one profession, but is cultivated by lawyers, physicians, artists, engineers, iron-masters and persons in every rank and walk of life. Some of the collections thus formed are valuable in a scientific point of view, on account of their being receptacles for specimens obtained in the prosecution of mining enterprises, or from local discoveries arising in the opening of quarries, the development of farm-lands, or cutting of canals and road-ways; thus preserving material which otherwise would be lost, and which ultimately must be handed over to the skilled mineralogist for accurate description and analysis. Other private collections are of deep interest on account of containing specimens of such exceeding rarity and costliness as to surpass aught that our colleges with their hitherto meagre endowments can display. This is especially true of the magnificent cabinet, some few of whose wonders I desire cursorily to describe in the present sketch, and which, by very general consent, is regarded as one of the finest collections in existence at the present time. This result has been achieved by an unsparing expenditure of money, time, and energy, not only in this country and Europe, but in every part of the world; extending to the sending out of paid collectors, the blasting of rocks in remote mountain-districts, the outbidding of all rivals when cabinets were offered for sale, and an unceasing watch over the fate of every unique specimen known to mineralogists. In some instances entire collections were purchased in order to secure a few remarkable specimens. To the man of science the collection affords the gratification of examining fine specimens of bodies so extremely rare that few persons have ever beheld them. The resources of the cabinet are most generously placed at the disposal of those engaged in any special mineral research; and, finally, the munificent owner proposes eventually to endow some institution of learning in this country with the perfected cabinet.

It is difficult to begin where so many objects worthy of study present themselves, and I shall not attempt a systematic description of this accumulation of minerals, which, though crowded together, can barely find room in eleven cases of drawers, a fire-proof safe and six glass show-cases. In the inclosed cases are more than 300 drawers, averaging about 25 specimens to the drawer.

But in the first place the tourmalines attract our attention. Of

these, a variety found near Gouverneur, in the State of New York, is distinguished by its peculiar brown color and internal structure. There is a suite of at least one hundred specimens of this variety alone, each one having been selected on account of some characteristic difference, and presenting together all the known and probably some yet undescribed crystalline faces. Some of the specimens are aggregates of crystals, one mass displaying fifty distinct terminations; others are individual crystals, frequently doubly terminated and showing the different arrangement of the planes upon the analogous and antilogous poles. The dimensions of one of these single crystals, reputed to be the largest ever found at Gouverneur, deserve a permanent record. It is four inches in height and four and a half inches through, with the rhombohedral faces of one termination almost perfectly developed, and with one rhombohedral face of the other termination four inches in width, the two other corresponding planes having been points of attachment to the rock. It is bounded by eighteen prismatic faces, all of which are perfect in form and polish.

Of the black tourmalines, there is one from Springfield, New Hampshire, which has a termination remarkable for the extreme development of the basal plane. It is $4\frac{1}{2} \times 3\frac{3}{4}$ inches across, and almost extinguishes the primary rhombohedron. Among entirely unique specimens from Greenland, Bovey Tracey, in Devonshire, England, Haddam, Connecticut, Norway and Sweden, we might mention a group from *Greenland*, of fifty or sixty crystals, mostly doubly terminated, and from four to six inches in length, forming a rosette with divergent crystals.

To the finely colored red tourmalines, which are frequently cut and polished as gems, the name of rubellite is given; those from Siberia being mostly violet red, the Brazilian rose-red; the specimens from Chesterfield and Goshen, Massachusetts, are pale rose-red and opaque; those from Paris, Maine, fine ruby-red. Among these rubellites there are six from Elba, of exquisitely delicate pink-color. They are hexagonal prisms, one of which is one and a quarter inch in height and three quarters of an inch in diameter, all implanted on a base that is itself very beautiful from the contrasted groups of rock-crystal, adular, and rosettes of mica, of which it is made up. Of rubellites from Elba there are more than fifty specimens, some of them reposing upon the native rock; others are terminated detached crystals of various shades of pink—also crystals on the gangue and fine detached rubellites from Siberia. When it is remembered that the slightest imperfection in the sharpness of an edge or angle, the scratching of a single face, excludes a specimen from this cabinet, and that none are admitted which are not at the same time remarkable for size, beauty, and perfection of crystalline form, the brilliant effect of a drawer filled with these natural gems can be imagined.

More than usual interest attaches to the mineral of which I am

now about to speak, the Columbite, on account of the derivation of its name and the history of its discovery. The rare metallic element columbium, or niobium as it has subsequently been called, was first discovered in 1802, by Hatchett, in a specimen of this mineral sent out by Governor Winthrop, of Connecticut, to Sir Hans Sloane, then president of the Royal Society, and the original analysis was made by Wollaston, with an accuracy truly surprising, upon only four grains of the specimen, so long ago as the year 1809. It is highly probable that Governor Winthrop's mineral came from Middletown, Connecticut, at which locality some very large crystals have since been found; among many such in the Spang collection, there is one composed of twenty-five crystals compounded together, and showing the terminal planes at the summit of each crystal. Two of the prismatic faces of one of these crystals are three inches in length.

There is a genus of minerals termed zeolites, from a Greek word signifying *to boil*, for the reason that when heated the large percentage of water which they contain escapes with intumescence, and of these one of the most remarkable species is scolecite, so called because, on touching it with the tip of a blow-pipe flame, it curls up like a worm. I find elsewhere the record of some crystals, which were found in the Berufiord, Iceland; and which exceeded two inches in length and were a quarter of an inch thick. There is a radiated mass of scolecite crystals in this collection, brought from Poonah, Hindostan, the largest being three inches in length, and compounded of two twins, each of which is one-quarter of an inch in diameter. The beauty of this group is still further enhanced by clusters of transparent tabular apophyllites attached to the sides of the crystals.

There is another species of zeolite, which, on account of its brilliant, pearly lustre, has received the name of stilbite. Usually its color is white; in this collection there is a specimen of stilbite from Poonah, that is compounded of a great number of individual crystals, the terminations of which together make up an octahedral summit with planes two inches wide. The color is a deep, rich salmon.

Of the apophyllites from the same locality, one of the most beautiful is a tabular square prism with the angles replaced by octahedral planes, all of which are perfect in lustre and surface polish. The crystal measures two and a quarter inches across, and is one and a quarter inch in height. There are remarkable suites of pink apophyllites from the Hartz, transparent green crystals, highly modified, from Nova Scotia, and some of the finest of those crystals which made the Erie tunnel through the trap-rock of Bergen Hill, New Jersey, at one time so famous among mineralogists. It is from such wonderful works as these that we are enabled justly to appreciate the transcendent skill with which Nature performs her task when she tries her hand at the plastic arts; for example, what piece of statuary could be so faultless, in grouping and finish, as one of these specimens,

which consists of thousands of apophyllite crystals, many of them an inch and averaging half an inch in size, festooned about a cluster of pendant stalactites?

Two uncut diamonds of great brilliancy are remarkable for the perfection of their forms; one is an octahedron with dodecahedral planes, the other is an elliptic twin, in shape closely resembling a heart. Each stone is of one carat weight, and entirely limpid and without a flaw—fit, in fact, for setting, though never touched by the lapidary. Less costly, but hardly less beautiful than these, are some Aragonites from Sicily, which are strikingly thrown into relief by the pedestal of lemon-yellow crystals of sulphur upon which they are mounted. They are six-sided prisms, measuring two and a quarter inches along the vertical, and two and a half inches along the lateral axis. Their bases and summits are perfectly plane.

At the time of its purchase and incorporation into the museum of Harvard University, I had the pleasure of critically examining the collection of minerals which had been accumulated by Herr Liebner, a mining-captain in the Tyrol. The finest specimens were a suite of Tyrolese epidotes, and I imagined that Nature could not surpass them, until I saw those in the possession of Mr. Spang. Among others of still larger dimensions, there is one prism of epidote which is eight inches in length, and three-quarters by one half an inch in thickness. It is perfectly straight, and all its sides and terminal planes are of a smoothness and lustre indescribable. The light transmitted through the crystal in one direction is a magnificent ruby-red, almost identical in tint with that exhibited by light-red silver-ore. Another crystal might fairly be entitled a gem of immense size; it is three inches in length, and exhibits thirteen terminal planes. On revolving it into different positions, the light passing through it changes in color from a delicate hair-brown to cherry and then to deep ruby-red.

Before concluding this sketch, some bodies of extreme rarity should be mentioned, among them the chloro-carbonate of lead, termed phosgenite. Most mineralogists are rejoiced to obtain minute crystals of this mineral, the large crystals from Crawford, near Matlock, in Derbyshire, having sold for from fifteen to twenty pounds sterling each. This cabinet contains a perfect prism, of strong adamantine lustre on all its faces, which is one and a half inch in height, one and a quarter broad, and one and an eighth in thickness. Still more rare is a mineral, of which singularly enough we possess as yet no satisfactory analysis, known as Turnerite, from the Tavetsch Valley in the Alps. In this collection there is a number of perfect crystals, five if I remember correctly, each of which displays many highly-lustrous facets, and occurring both isolated and embedded in a rock made up of quartz and albite. The largest crystal is three-quarters of an inch long and five-eighths of an inch thick. It is a doubly-terminated hexagonal prism, the basal edges being regularly replaced by twelve small planes. The

color is a translucent *green*—in most other recorded cases it is yellow or brown.

One of the most curious specimens is a natural amalgam of silver. It is a dodecahedral crystal, one-half an inch by three-eighths in size, which communicates, by a solid rod of the same material passing through the interior of the rock and nearly concealed from view, with a similar crystal of amalgam. When placed in such a position that one crystal is vertically above its mate, and allowed to stand for a short time, the mercury finds its way downward and distends the lower crystal until its faces are quite obliterated. In fact, it is converted into a pear-shaped drop, and looks as if it were about to fall from the crystal. When the specimen is inverted and allowed to remain so for half an hour, the mercury percolates through the solid mass of amalgam, the distended crystal acquiring its former definite outlines, and settles into a drop depending from the apex of crystal No. 1. This *lusus naturæ*, an hour-glass of metallic crystals, is, I believe, without parallel.

Then there is a resplendent crystal of axinite from Switzerland, among multitudes of others, which is three inches upon one of the faces and four inches measured along its greatest dimension; and a cluster of stibnite crystals from Hungary, weighing perhaps five pounds, of which the largest crystal is a prism three inches long and three-eighths of an inch thick, perfectly terminated.

In conclusion, the emeralds deserve our admiration, as they would that of persons least sensible of natural beauty. Of these, there is a number of large crystals, some mounted upon the rock in which they occur, others detached. Some of the latter from Bogotá have highly-modified terminations. Although not so large as the others, being but one-half an inch in length and three-eighths of an inch in thickness, by far the finest emerald is one which is implanted, along with smaller crystals, upon a piece of rock from the Ural Mountains. It has a perfect termination, presenting very many rhombohedral and pyramidal planes. Without a flaw, absolutely limpid, and of wonderful purity and depth of color, it is a natural gem, in the eyes of a mineralogist incomparably more beautiful than any cut and polished jewel could be. Its history might suggest to the writer of fictions some features of a romance, it having been given by a Czar of Russia to Taglioni, and subsequently placed by her in pawn with a wealthy gentleman in Paris.

A FREAK OF NATURE.

THERE were recently exhibited in Berlin and Paris two individuals who attracted much attention among scientific men, owing to a very singular development of hair upon the face and neck. In Paris they received the appellation of *hommes-chiens* (dog-men), from the resemblance of the adult's face to that of a Skye terrier. The portrait here given of Andrian Jeftichjew hardly does justice to this striking resemblance, though in other respects it is a faithful representation of the man's curiously hirsute countenance. Andrian is about fifty-five years of age, and is said to be the son of a Russian soldier. In order to escape the derision and the unkind usage of his fellow-villagers, Andrian in early life fled to the woods, where, for some time, he lived

FIG. 1.

ANDRIAN JEFTICHJEW.

in a cave. During this period of seclusion he was much given to drunkenness, and even yet he is said to live chiefly on *sauer-kraut* and *schnapps*. His mental condition, however, observes a medical journal, does not seem to have suffered, and he is, on the whole, of a kindly and affectionate disposition to his son and those about him. It may be of interest to state that Andrian is an orthodox member of the Russo-Greek Church, and that, degraded as he is intellectually, he has very definite notions about heaven and the hereafter. He hopes to

introduce his frightful countenance into the court of heaven, and his present tour may be regarded as a sort of preparation for death, as he devotes all the money he makes, over and above his outlay for creature comforts, to purchasing the prayers of a devout community of monks in his native village, Kostroma, after his mortal career is ended.

Andrian is of medium stature, but very strongly built. His excessive capillary development is not true hair, being simply an abnormal growth of the *down* or fine hairs which usually cover nearly the entire surface of the human body. Strictly speaking, he has neither head-hair, beard, mustache, eyebrows, nor eyelashes, their place being taken by this singular growth of long, silky down. In color this is of a dirty yellow; it is about three inches in length, all over the face, and feels like the hair of a Newfoundland dog. The very eyelids are covered with this long hair, while flowing locks come out of his nostrils and ears. On his body are isolated patches, strewed, but not thickly, with hairs one and a half to two inches long. Dr. Bertillon, of Paris, compared a hair from Andrian's chin with a very fine hair from a man's beard, and found that the latter was three times as thick as the former; and a hair from Andrian's head is only one-half as thick as an average human hair.

FIG. 2.

FEDOR JEPTICHJEW.

When these strange beings were exhibited in Berlin, Prof. Virchow was much interested in them, and gathered all accessible information about their life and ancestry. He states that Andrian is, so far as known, the first of his line to present this wonderful hirsuteness. Neither his reputed father nor his mother presented any peculiarity of

this kind, and a brother and sister of his who are still living are in no wise remarkable for capillary development. Andrian married and had two children, who died young; one of these was a girl, who resembled her father; but of the other, a boy, nothing can be ascertained.

Fedor, whose portrait we give, is Andrian's illegitimate son, and is about three years of age. He is a sprightly child, and apparently more intelligent than his father. The growth of the down on his face is not yet so heavy as to conceal his features, but there is no doubt that when the child comes to full maturity he will be at least as hirsute as his parent. The hairs are as white and as soft as the fur of the Angora cat, and are longest at the outer angles of the eyes; there is a thick tuft between the eyes, and the nose is well covered. The mustache joins the whisker on each side, after the English fashion, and this circumstance gives to accurate portraits of the child a ludicrous resemblance to a well-fed Englishman of about fifty. As in the father's case, the inside of Fedor's nostrils and ears has a thick crop of hair.

It is remarkable that both Andrian and Fedor are almost toothless, the former possessing only five teeth, one in the upper jaw and four in the lower, while the child has but four teeth, all in the lower jaw. These four teeth are, in both cases, the incisors. To the right of Andrian's one upper tooth there still remains the mark of another which has disappeared. That beyond these six teeth the man never had any others is evident to any one who feels the gums with the finger.

Buffon, in the supplement to his "Natural History" (1774) mentions a native of Russia, whom he had seen, and whose entire face was covered with hair. But a more exact counterpart of Andrian is found in a Burmese family living at Ava, and first described by Crawford, an English traveler, in 1829. At the time of Crawford's visit to Ava, Shwe-Maong, the head of this family, was about thirty years of age. His whole body, except the hands and feet, were covered with silky hairs, which, on the shoulders and along the spine, attained the length of five inches. Shwe-Maong arrived at puberty at the age of twenty years, and it was only then that he lost his milk-teeth, which were replaced by five teeth in the upper jaw, one canine and four incisors, and four incisors in the lower jaw. He had four daughters, one only of whom resembled her father. She was found living at Ava by a British officer in 1855, who states that her son was hairy like his grandfather, Shwe-Maong.

In "Animals and Plants under Domestication," Darwin mentions Julia Pastrana, a Spanish dancer, or opera-singer; she was "a remarkably fine woman, but she had a thick, masculine beard, and a hairy forehead; she was photographed, and her stuffed skin was exhibited for a show. . . . From the redundancy of her teeth, her mouth projected, and her face had a gorilla-like appearance." A writer in the French journal *l'Illustration* gives us a fuller account of this woman.

"She was of very dark complexion," says he, "short of stature and well proportioned; her hands and feet were small, her nails yellow; she had a beautiful breast. Her tresses were very long, deep black, and coarse as horse-hair, and she had a strong beard. Her forehead was overgrown with hair, down to the bushy eyebrows, which overshadowed her soft, humid eyes within their border of black lashes.

FIG. 3.

JULIA PASTRANA.

Her face was made specially hideous by the excessive development of the half-open lips; she spoke with difficulty, and sang mezzo-soprano in Spanish. The parts having the heaviest covering of hair were the shoulders and the hips, the breast and the spinal column. On the limbs the hairiness was greatest on the inner side."

Mr. Darwin recognizes the existence of a constant relation between the hair and the teeth, and cites the deficiency of teeth in hairless dogs. He says that in those exceptional cases in which the hair has been renewed in old age, this has "usually been accompanied by a renewal of the teeth." According to him, the great reduction in the size of the tusks in domestic boars probably stands in close relation with their diminished bristles. Then, after referring to the Burmese family and Julia Pastrana, Mr. Darwin says: "These cases forcibly call to mind the fact that the two orders of mammals—namely, the Edentata and Cetacea—which are the most abnormal in their dermal covering, are likewise the most abnormal by deficiency or redundancy of teeth."

CORUNDUM.

WITHIN the past two years, the attention of the scientific world, especially, has been directed to the above mineral, from the fact of its discovery, in place, in this country. A number of communications on the subject have been published by prominent men, the most important of which are those from Profs. Genth and Lesley, of the University of Pennsylvania; Prof. Charles U. Shepard, of Amherst College; Dr. A. C. Hamlin, of Bangor; and Dr. J. Lawrence Smith, of Kentucky. These papers are mostly of value to men of scientific pursuits. Our readers will be interested in more detailed information as to this mineral, and the locality where first in the history of the world it is legitimately mined.

Although corundum has been in use, as an abrasive, from an early age, and under various names, it was not until near the commencement of the present century that its localities were found and examined by scholars, and its true place in mineralogy determined. For thousands of years the Chinese had used it, under the name of adamantine spar; the Persians, as Armenian whetsone; the Hindoos, as corundum; and the Egyptians, as the iron-stone of the Red Sea. The natives of these countries had gathered it from the beds of mountain-torrents, or in the alluvium of the valleys, after the annual rains had washed it down, freeing it, in the transit, from its associate minerals and impurities; but no attempt at its legitimate mining had ever been made until within the past two years, in the United States, in the State of North Carolina. The mineral, from whatever locality it comes, is now known in science and commerce as corundum—the name given it by the Hindoos, and meaning cinnamon-stone, from the resemblance in color to that article, of the variety found in their country. It is pure crystallized clay or alumina, and is the next hardest substance in Nature to the diamond, reducing to powder all substances save that gem.

Until the researches of Haüy, the distinguished French *savant*, about the commencement of this century, the three forms of alumina, known as sapphire, corundum, and emery, were supposed to be distinct species. His analysis made them three varieties of one species; a decision confirmed by chemists since, and now universally accepted. The earliest extended reference to corundum, of any value to science or trade, appears in a joint paper by Count Bournon, of Paris, and Sir Charles Greville, of London, prepared for the Royal Historical Society of London, in 1798; which was soon followed by a more careful mineralogical treatise, by the first-named scientist, prepared by him for the same society. Sir Charles Greville's observations were

based on data collected by him at a point in the alluvium in India where the natives had for ages gathered the mineral. Those by Count Bournon were the results of his studies of the mineral at Paris, from specimens brought him from several points, especially in India and Ceylon. At a later date, we have interesting information from Sir Alexander Burnes as to the celebrated ruby locality of ancient Bactria; and from Sir James Tennent and Sir Samuel Baker, as to the famed sapphire districts of Ceylon, which were carefully examined by them during a protracted residence there. A most interesting account of these localities was also published in the *Ceylon Observer* for June, 1855, by Mr. William Stewart, of Colombo. In the *American Journal of Science* for the years 1850, 1851, and 1866, are three papers on granular corundum, or emery, by Dr. J. Lawrence Smith, of Kentucky; the first two descriptive of the emeries of Asia Minor, and localities on the islands of the Ægean Sea; the third, on the mine in Western Massachusetts, known as the Chester mine. These papers are of the first importance in all questions concerning the commercial emeries of our own or foreign countries, and cover the ground of investigation to the date of the North Carolina discovery, and the communications thereon, enumerated in the opening paragraph of this article.

Up to the date of 1871, corundum, or its gems, had never been found *in situ*. Both were looked for in mountain-torrents, or beds of gravel at their base. Emery had for many years been mined in the islands of the Ægean Sea, but had not been scientifically studied in position, until the researches of Dr. Smith, alluded to; since which date, however, it has been found in place at various points in our own and other lands. About the year 1800 it became known that corundum existed, in small quantities, all along the mountain-line of seacoast, from Maine to Georgia; and, twenty-five years since, it was found in bowlders, in considerable quantities, in Southeastern Pennsylvania. Near the same time a large fragment of massive sapphire was picked up in Western North Carolina, and elicited much attention from mineralogists; but, careful further search in the locality for it being fruitless, there has been since but little effort to find it at any point in the Appalachian range. Whatever effort was made, however, settled the point that corundum existed, in considerable quantity and different degrees of purity, at twenty-five or more localities scattered from New York to Northern Alabama.

In the spring of 1871 Colonel C. W. Jenks, of St. Louis, being in want of an abrasive more powerful than Naxos emery, started out into the mountains of Tennessee and North Carolina in search of corundum, in sufficient quantity to mine profitably. From many localities where the mineral showed itself, he selected one near the head-waters of the Tennessee, in Southwestern North Carolina, nine miles east from Franklin, the county-seat of Macon, and commenced his work. A

large price was paid for mountain-land, at a site where the mineral had been found on the surface in considerable quantities. A canal was cut from a mountain near, that furnished hydraulic power; a gang of a dozen mountaineers were engaged as miners, and ground was first broken in the search for corundum in position. There being no precedent or guide in mining for corundum, experience was the teacher, and a dear one, for nearly a year of energetic and toilsome exploration. The question to be solved was, whether the mineral in any quantity lay beneath the surface, upon which, all former supplies had been gathered; and, if so, whether it would show itself in bowlders, segregated masses, pockets, or true veins. The country rock is granite and gneiss; the spur or ridge, where the mineral showed itself, a trap of chromiferous serpentine, or chrysolite formation. The strata developed is chrysolite rock, mixed with anthophyllite—a layer of micaceous rock—a seam of chalcedony—a stratum of chlorite, of the variety ripidolite, and a gangue of the same, which proves to be the usual matrix of the corundum. Eight months of hard labor settled the question that corundum was there in immense quantity, and that it would be found in veins varying, as is usual in other minerals, from a few inches to several feet in width. These should be termed, what they are, embedded veins, between hanging and foot walls of chrysolite, the gangue being of various minerals—generally, however, of ripidolite, as stated; but sometimes that mineral running into mica schist, talc, spinel, jefferesite, and feldspar. In one of these veins, in a pocket of jefferesite—a golden-yellow mica—there was found much the largest and finest crystal of corundum known, of a fine sapphire and ruby color, weighing 312 pounds, and now the property of Prof. Shepard, of Amherst College. This unique specimen would undoubtedly command one thousand dollars, were it for sale, various collectors of Europe being anxious for its possession. Corundum from this mine proves to be of excellent quality. Taking sapphire as the standard at 100, the product of the mine has a power of from 90 to 97 as an abrasive, while that of the best emery, the Naxos, numbers from 40 to 57. The veins, five of which have been opened, run northeast and southwest, dip under at an angle of 45°, and are, at the deepest point reached, seven to ten feet wide. There is also remarkable association of other interesting minerals of tourmaline, spinel, zerkon, etc., while the corundum itself shows almost every shade of color from white to black. It is also remarkable that the mine contains all the varieties in color, texture, and crystallization, found in the aggregate corundum localities of the globe. Association of two colors in the same crystal is spoken of by the best writers as a somewhat rare matter, even in Ceylon. One crystal was shown us from this mine, weighing two pounds, with blue, ruby, pink, yellow, and green colors of great brilliancy and transparency; and a small hand-collection, which contained a variety in form, perfection, and purity of color, not equaled

by any collection of corundum in the known cabinets of Europe—for from no other locality have such specimens been found, excepting in the perfect gems from Ceylon and Burmah.

We now come to the most interesting feature of the mine. It was natural that, with so much of purity in the amorphous mineral, and perfection and beauty in the crystals found with it, Colonel Jenks should conclude that there might be gems in the mine. But from no quarter but his own observations did he get any encouragement in this direction. The best English authority on gems and their localities, Prof. King, of Trinity College, Cambridge, says: "The corundum gems have never been found in place, but always in the alluvial or sands of the rivers." After eight years of residence in Ceylon, the source from which the best sapphires of the world have come from an early period, and much acquaintance with the best gem-localities of the island, Sir Samuel Baker remarks: "The sapphires were created in the peculiar secondary formation, where they are always found, which is composed of water-worn pebbles, in a conglomerate of blue and white clay, buried ten to twenty feet beneath the surface of the valleys," etc. This was the opinion of Buffon, and other eminent scholars. The ruby localities of Bactria, visited by Sir Alexander Burnes, are said by him to be of similar character. Sir James Tennent, in his elaborate work upon Ceylon, expresses similar views, yet ventures the opinion, from a survey of the whole subject, that gems might be found in place in the island. He says, in confirmation of this view, that he saw in one of the mountain-ranges "a stratum of gray granite, with iron pyrites and molybdena, which contained great quantities of very small rubies." Whether he ascertained the nature of the gems he calls rubies by analysis, or only from casual observation, he does not say; but garnets of great beauty so often occur in such a matrix that it would not be safe to rely on those stones he saw—unless analyzed—as the ruby corundum. Seeking information from a later, and perhaps we are justified in saying, on this matter, the most eminent authority, that of Dr. J. Lawrence Smith, of Kentucky, he says, in substance: "The gems of corundum cannot be expected to appear where the amorphous masses of the mineral abound, and, *vice versa*, that corundum, for commerce, will not be found with the precious gems," etc., his conclusion being based upon "the diverse composition of the two forms of the mineral, shown by analysis, and which would require for their formation different geological and mineralogical conditions," etc.

Not dismayed by this array of scientific opinion and experience, however, Colonel Jenks made careful examination of the material as it came from the miners' hands, and the results led him to give them special instructions as to the nature of their operations. As the geodes in the formation of silica have been found to contain the finest quartz crystals, he hoped to find in the mine something of the same character, of alumina. He was rewarded by one or more large pockets of geodes

of dark-green chlorite, from the size of a walnut to that of a fifty-pound shot, within which were one or more crystals of corundum, sometimes blue and white, and, in few instances, of ruby color. None of them were entirely transparent; none of the geodes had cavities, as is the case in those of quartz formation; yet the prospect in this direction is most promising. The result thus far, however, is most encouraging in the rock-strata itself, which is the proper gangue of the corundum. With the hundred tons the mine has yielded for abrasive purposes, the workmen have taken from the place of their birth—a solid, undisturbed matrix of ripidolite—beautiful specimens of the nine corundum gems known by lapidaries by the prefix "Oriental," because of their superior hardness and brilliancy; and also because those of this character, in lustre and composition, were first brought from the East. These are known by name as Oriental sapphire, ruby, emerald, topaz, asteria, amethyst, chatoyant, girasol, and white or colorless sapphire, this last often used in place of the diamond. The general characteristics of these stones, such as color, lustre, hardness, etc., are, by the first lapidaries of this country and Europe, pronounced as not inferior to those of the best localities of the Old World. One of them was sold to a lapidary of Amsterdam, Holland, for $4,000. Others of much beauty have been cut, and are owned in this country and Europe. In this connection it is of value to note that Count Bournon, during his investigations, made a list and analysis of the associate minerals found, *in transitu*, with the sapphires of Ceylon. Colonel Jenks has had a similar list and examination made of those found *in situ* with the gems of his mine. All the minerals found in the Ceylon gem-deposits are found in the North Carolina locality.

There can be no doubt, therefore, that Colonel Jenks has made the discovery, in America, of the most precious gems next to the diamond, where they have been sought for in vain elsewhere, *in a matrix of solid rock-formation.* We look for further interesting developments at this unique and thus far unparalleled alumina deposit.

ATMOSPHERIC ELECTRICITY AND OZONE: THEIR RELATION TO HEALTH AND DISEASE.[1]

By GEORGE M. BEARD, M. D.

AMONG the published list of questions at the civil service examination of the Board of Health of New York last summer I observed this: "What is the composition of pure air?"

[1] Read before the American Public Health Association, in New York, November 13, 1873. It was voted by the Society to publish this paper in their "Transactions," but, through the courtesy of the Secretary, the author is allowed to publish it independently.

As I laid down the paper I asked myself this question, or, rather, I put to myself the same question in another form: "Is there among the sons of men any one who really knows the composition of pure air?"

Still further I queried with myself what answer I should have given to the question had I been one of the applicants for a position on the Board of Health, and it seemed to me that, after stating what almost every school-girl knows about the relative proportions of oxygen and nitrogen, I should have added this codicil: "The question of the composition of pure air is one that is too complicated to admit of an answer." What I have to say this morning on atmospheric electricity and ozone will serve, so far as it goes, to enforce this view.

How the Subject of Atmospheric Electricity and Ozone has been investigated.—During the past quarter of a century regular daily observations of atmospheric electricity have been made in Brussels, Munich, and for the past ten or fifteen years in St. Louis. The difficulties in the study of the subject are very great, but, from the accumulated observations of the different investigators, some few interesting and important general facts have been secured.

Apparatus for studying Atmospheric Electricity; Measuring Apparatus.—Prof. Dellman, of Kreuznach on the Rhine, for several years made three regular observations each day of the atmospheric electricity. The electrometer that he used in these observations is a torsion balance. A small thread of glass going vertically through a glass tube has on its lower extremity a small needle of brass fastened to it. This light brass needle, when influenced by any force, can move over a metallic disk with a graduated scale. Below this light brass needle is another light brass needle, which is fixed and isolated from the metallic disk, and connected with a metallic wire which receives the electrical charge from outside. By means of a micrometer screw the upper needle can be lowered and raised so as to touch the lower needle, or be kept above it.

The whole instrument rests on three iron legs, which can be screwed up and down so as to give it the level required. When the wire outside receives a charge of electricity, it communicates this charge to the lower needle. If, now, the upper needle be lowered and brought in contact with the lower one, it also receives a charge of electricity. But, as like electricities repel each other, the other needle will be at once driven off over the graduated scale. The number of degrees that it is driven will depend on the strength of the charge. To determine whether the electricity is positive or negative, subsequently charge the wire with electricity of known quality. If they are alike—that is, if the first charge be of the same quality as the second—the needle will be repelled still farther; if unlike, the needle will return toward the fixed needle.

Collecting Apparatus.—Dellman's apparatus for collecting atmospheric electricity is a hollow brass or copper ball about six inches in diameter, with a stem of metal. The metallic stem rests in a metallic tube, but is isolated from the tube by shellac. This apparatus is attached to a pole almost thirty feet long. This pole is drawn by a windlass up the walls of a house to the top of the roof. The operator then touches the stem of the ball with a piece of brass in the shape of a half-moon. This charges the ball with electricity. The pole is now let down at once, and the collecting apparatus is brought in control with the measuring apparatus. The electricity which is thus collected in the ball is developed in it by induction. The natural electricity of the ball is separated by the surrounding atmospheric electricity into positive and negative electricity. One of these goes to the lower part of the ball, the other remains in the upper part. Atmospheric electricity is usually positive. The natural electricity of the ball being decomposed, the negative is attracted to the upper and the positive to the lower part. When the operator touches the stem of the ball with the piece of brass, the positive electricity is conducted through his body to the ground, and the negative remains in the ball.

When, therefore, the electrometer shows negative electricity, it indicates positive electricity in the atmosphere, and vice versa.

It has been shown that there are two daily tides of positive atmospheric electricity—the high tides between 9 and 12 A. M. and between 6 and 9 P. M.; the low tides between 2 and 5 P. M. and 1 and 5 A. M. The annual variations are fully as marked as the diurnal; the quantity of positive atmospheric electricity being greatest in the winter, least in the summer. Dr. Wislizenus found that, in 2,124 observations made at regular hours, the atmospheric electricity was 2,046 times positive and but 78 times negative. Of the 78 times, 30 were connected with thunder or hail storms, or by thunder and lightning, 23 by common rains, and 20 by high winds and gales without rain, thunder, or lightning, 4 by snow, and 1 by fog.[1]

According to Herschel, out of 10,500 observations at the Royal Observatory, only 364 showed negative electricity. The remainder, 10,176, all showed positive electricity. Negative electricity was usually attended with rain.

It seems, therefore, that the chief cause of a condition of negative atmospheric electricity is storm, and especially thunder-storms, and that at all other times positive atmospheric electricity prevails. In very many cases this change to negative electricity takes place shortly before the storm approaches; during its progress there may be—especially in thunder-storms—rapidly-repeated alternations of positive and negative conditions, followed by an equilibrium, or by positive electricity.

Dr. Wislizenus, of St. Louis, also found that snow-storms and fog

[1] Dr. A. Wislizenus, in Transactions of St. Louis Academy of Medicine.

were usually accompanied by an increase of positive electricity; this observation is of interest, because it accords with the fact that the approach of snow-storms and the presence of simple fog do not cause the exacerbations of rheumatic and neuralgic pains that are experienced on the approach of storms of rain, or thunder and lightning.

Ozone-History.—From the earliest recorded ages a peculiar odor has been observed during thunder-storms and other electrical disturbances, and especially in connection with flashes of lightning. The peculiar odor of thunder-bolts has been referred to by Homer, both in the "Iliad" and the "Odyssey." Jupiter is said to strike a ship with a thunder-bolt, "ἐν δὲ θέειου πλῆτο," full of sulphurous odor, and to hurl a bolt into the ground "with the flame of burning sulphur." This peculiar sulphurous odor has been observed not only during thunder-storms, but also, it is said, during displays of northern and southern auroræ.

So long ago as 1785, Van Marum, of Holland, observed that electric sparks passed through oxygen gas (that had been discovered by Priestley only eleven years before) gave rise to a peculiar sulphurous or electrical odor; and, at the beginning of the present century, Cavallo, a prominent name in the history of electricity, called attention to the fact that this "electrified air," as it was termed, had an antiseptic effect on decomposing matter, and was a salutary application for fetid ulcers. In 1826 Dr. John Davy, in a measure anticipating Schönbein, recognized this peculiarity of the atmosphere, and devised tests for detecting it.

The real scientific history of ozone dates from 1839, when Prof. Schönbein, of Basle, the renowned inventor of gun-cotton, observed that the electrolytic decomposition of water was attended by a peculiar odor resembling that evolved during the working of a frictional electric machine. In 1840 Schönbein called the attention of the scientific world to the newly-discovered substance, to which he gave the name of *ozone*, from the Greek ὄξω, to emit an odor. He showed that this odor appeared at the positive pole during the electrolysis of water. He furthermore pointed out that ozone may be produced by the slow oxidation of phosphorus in moist air or oxygen, and that the odor was similar to that which is observed during flashes of lightning. Schönbein studied hard on the subject for many years, and arrived at the conclusion that oxygen is capable of division into a negatively polar state, ozone, and a positively polar state, which he called *antozone*. During the past quarter of a century the subject of ozone has been studied by some of the most eminent scientists of the age, among whom we may mention the names of Berzelius, De la Rive, Marignac, Becquerel, Faraday, Fremy, Meissner, Houzeau, Scoutteten, Odling, Andrews, Tait, Fox, Fischer, Boeckel, Zeuger, Moffat, Nasse, Engler, Erdmann, Angus Smith, Poey, A. Mitchell, Soret, Baumert, Williamson, and very many others.

The Nature of Ozone and Antozone.—The result of this quarter of a century of research, is the present conclusion that ozone is *condensed allotropic oxygen.*[1] In regard to antozone there is much difference of opinion among scientists. There are those who declare that it is a myth. The original hypothesis has recently been losing its hold on the scientific mind, and further researches are necessary to determine what it is and what it is not. The present opinion of the German philosophers is, that antozone is the *peroxide of hydrogen diffused through the air.*

Preparation of Ozone.—Ozone is prepared in various ways—by passing electric sparks, or electricity without sparks, through oxygen or air, by the electrolysis of acidulated water, by oxidizing phosphorus in moist air, by the action of strong sulphuric acid (three parts) on permanganate of potash (two parts), by sending water in the form of spray through air, by introducing hot glass rods into vessels filled with the vapor of ether, and by the slow oxidation of ethers and oils, etc., when exposed to light.

Properties of Ozone.—Ozone is a colorless gas, with a powerful and peculiar odor. Like oxygen, it is an oxidizing agent of great power. It changes indigo into *isatin*, the black sulphate of lead into the white sulphate of lead. It oxidizes antimony, manganese, arsenic, iron, zinc, tin, silver, lead, bismuth, and mercury. Many of the lower oxides it transforms into peroxides. It corrodes India-rubber and decolorizes blue litmus-paper. It acts with great rapidity on iodide of potassium, liberating the iodine. It quickly consumes ammonia, changing it into nitrate. It decomposes *hydrochloric* acid, liberating the chlorine. It is insoluble in acids, alkalies, alcohol, ether, the essential oils, and water. The odor of ozone is very penetrating; air containing but one millionth of it is said to be perceptible to the olfactories. The peculiar odor of sea-air is in part the result of ozone. All air, even the purest, has more or less ozone; but so accustomed do we become to it that it is only by sudden change into it that we perceive it. Visitors at the Mammoth Cave, Kentucky, report that, on emerging, the air has a peculiar and vivid odor such as they never before realized. That we can in a half-hour become so used to the foul air of a closed room that we do not perceive its odor until we leave it for a few moments and then return to it, is the experience of every one. The peculiar odor of ozone can be obtained very easily indeed by touching a metallic electrode of a galvanic battery of a number of cells against one of the plates of the batteries so as to make a connection of the current, or by touching the metallic ends of the poles for a moment with the spark thus produced.

Ozone in the Atmosphere.—Ozone, like electricity, exists normally in the atmosphere, but varies in amount in different localities at differ-

[1] "Ozone and Antozone: their History and Nature." By Cornelius B. Fox, M. D. London, 1873.

ent seasons and in different hours of the day, and is considerably dependent on various meteorological conditions.

It varies with the Locality.—It is more abundant in the country than in the city; by the sea-side than inland; among mountains than in valleys; in well-drained neighborhoods than in those where such sanitary provisions are disregarded. The opposite results of different observations in different localities are accounted for in part by the fact that the amount of ozone is not everywhere constant. Ozone is not often found in closed rooms or chambers. Those who stay in-doors are deprived both of atmospheric electricity and ozone. Like electricity, it increases with the altitude; hence we may in part explain the beneficial effects of mountain-air. The air of the sea is richer in ozone than the air of the land, because evaporation is attended with the simultaneous development of oxygen and ozone. Hence it is that tests applied over the surface of the sea or of lakes, ponds or rivers, show a deeper tint than tests applied over the land. An excess of sea-air will blight vegetation in the vicinity of the ocean; delicate fruits, as the peach and the plum, are cultivated only with difficulty. It has been observed that a prolonged storm coming from the sea will blight vegetation. Possibly the excess of ozone may be a factor in this destruction.

It varies with the Season.—Ozone, like electricity, is more abundant in the winter than in the summer. Atmospheric ozone is not measured with the same accuracy as atmospheric electricity, and therefore the regular gradations during the spring and autumn have not been established as in the case of the latter agent. For the same reason there is much discrepancy among different observers. It is believed that the relatively small amount of ozone in the summer and early fall is due partly to the fact that it is consumed in oxidizing the impurities of the air, and partly to the fact that there is less atmospheric electricity at that time.

It varies with the Hour of the Day.—There is considerable difference in the conclusion of different observations, but the average results seem to show rather more ozone in the atmosphere during the night than during the day. Like atmospheric electricity, ozone rises and falls in pretty regular tides twice during the twenty-four hours. The maximum periods are between 4 and 9 A. M. and 7 to 9 P. M. The minimum periods are between 10 A. M. and 1 P. M. and between 10 P. M. and midnight. It will be seen that ozone is at its minimum when the sun is at the zenith, and its maximum about sunrise and sunset. It varies with atmospheric conditions, as electricity, rain, fog, thunder-storms, snow, wind, clouds, halos, and auroras, eclipses, etc. There is a certain correspondence between the tides of electricity and of ozone; they seem to rise and fall together. This will be apparent on comparing the statements made above. A comparison between atmospheric ozone and electricity has been made by Quetelet, who has given the subject special attention. His obser-

vations, which were made with Peltier's electrometer in August, 1842, are represented in the following table:

Hours.	Electricity.		Ozone.	
6 A. M.	+17	.....	4.10	
7 "	27		4.60	
8 "	36	Maximum.	4.88	Maximum.
9 "	27		4.45	
10 "	20		.31	
11 "	14	.....	.41	
12 M.	12	.....	.80	Minimum.
1 P. M.	10		.96	
2 "	5		1.17	
3 "	3	Minimum.	1.31	
4 "	5		1.40	
5 "	11		1.33	
6 "	18	.....	1.33	
7 "	24		1.41	
8 "	30		1.56	Maximum.
9 "	32	Maximum.	1.70	
10 "	30		1.00	
11 "	19	.....	1.15	

Ozone, like electricity, seems to depend in a measure on the humidity of the air. The relation of fog to atmospheric ozone is not yet determined, but it seems to be agreed that during snow-storms it is increased. Thus, Wolf gives the following comparison:

Amount of atmospheric ozone in fine days, 4.186.

Amount of atmospheric ozone in rainy days, 11.40.

Amount of atmospheric ozone in snowy days, 14.15.

It will be remarked that snow-storms also favor atmospheric electricity. The direction of the wind has a certain influence, as is well recognized, on ozone. According to Lowe, ozone is most abundant during a southwest or south-southwest wind, and least abundant when the wind is north or northeast. There is a maximum when the barometer is low, and a minimum when it is high. Other inland observers agree with Mr. Lowe. At the sea-side, winds blowing from the sea bring with them abundant ozone.

When the sky is darkened with clouds, there is more ozone than when it is clear. Before thunder-storms, or while they are at a distance, ozone, like electricity, increases, and various changes and fluctuations may occur during the progress of the storm.

Summing up in a few words, we may say that atmospheric ozone is more abundant during the winter and spring, because in those seasons there is much rain, snow, hail, and wind, a low temperature, and a maximum of electricity. During these seasons, also, there is little decomposition going on in the vegetable world. In the summer and autumn, atmospheric ozone is least abundant, because, during these seasons, there is no snow, or hail, less wind, rain, high temperature, a minimum of electricity, and a great amount of decomposition of animal and vegetable matter, by which the air becomes polluted, and is neutralizing and purifying while the ozone is consumed.

Average Quantity of Ozone in the Atmosphere.—The quantity of ozone in the atmosphere is exceedingly minute. The proportion varies with the locality, the season, the hour, etc., as we have already seen, and it also varies with the altitude, for it is with this agent as with electricity—it increases as we rise above the earth. According to Houzeau, air of the country, about six feet above the earth, contains about $\frac{1}{450000}$ of its weight of ozone, or $\frac{1}{700000}$ of its volume. The quantity is so minute that it may probably be increased several fold without perceptible injury to man or animals.

Origin of Atmospheric Electricity and Ozone.—The sources of ozone in the atmosphere are almost innumerable. Like atmospheric electricity, it results from a wide variety of countless and ever-changing influences; it is one of the grand resultants of the ceaseless chemistry of the earth and sky. The evidence is now pretty clear that one prominent source of atmospheric ozone is in vegetable life. The oxygen that plants evolve from their leaves is more or less ozonized. It is claimed that ozone is developed with the perfume of flowers. The most odorous flowers, as the heliotrope, hyacinth, and mignonette, are the most prolific generators of ozone. This ozonic property of flowers is most manifest under the direct influence of sunlight. Lavender, fennel, mint, clove, and cherry-laurel, evolve ozone with special abundance when exposed to the solar rays. It is believed that the oxidation of essential oils, as anise-seed, bergamot, etc., under exposure to the light and air, develops ozone, and that in all flowers the source of the ozone is the essence; hence it is that the most odorous are the most ozoniferous.

If we accept these conclusions, we must also concede that the custom, now almost forgotten, among physicians, of providing the handles of their canes with vinaigrettes, with the fancy that the fumes would protect them against infectious disease, has a certain scientific basis. The aroma of snuff is said to develop ozone, and for years snuff has been regarded as a disinfectant.

Electricity, as is well understood, is generated by any kind of chemical change or action. Even friction and pressure cause electricity to be evolved, as was shown by Armstrong's experiments with jets of condensed air, liberated under high pressure. It was shown by Faraday that the friction of water dropping against bodies gives rise to electricity, and it is probable that the same effect follows the friction of water against air.

Volta showed, nearly a century ago, that the spray of a fountain furnishes negative electricity. Trolles, and afterward Humboldt, observed that a cascade or water-fall filled the air for some distance with negative electricity, and Bell thinks he has proved that a cascade is negative at the top, and positive at the bottom; that the positive electricity passes into the earth, leaving the negative in the spray.

We are then to look for the sources of ozone, as of electricity, in all

the infinite play of the terrestrial powers: in the falling away of the rocks, and the springing forth of plants; in the oxidation of metals, and the emission of the perfume of flowers; in the deposition of dew, in the falling rain, the rattling hail, and the drifting snow; in the rushing of the wind, and the conflict of the storm; in the friction of the clouds as they pass in the sky, or rest on the summits of the mountains; in the ceaseless evaporation on sea and on land; in the rushing torrents of the hills and the dashing breakers on the shore.[1]

Ozone a Disinfectant.—The disinfecting powers of ozone have long been noted. It is one of Nature's great purifiers. It is sometimes generated artificially in hospitals and public buildings. It acts both on animal and vegetable matter. According to Schönbein, air containing but $\frac{1}{3240000}$ of ozone is capable of disinfecting its own volume of air filled with the effluvia, evolved in one minute, from four ounces of highly-putrid flesh.

Ozone, in disinfecting and purifying decaying and putrid matter, is itself destroyed. It dies, that others may live. Hence it is that there is so little of ozone in the air of towns and cities and villages, and in hospitals. The ozone is consumed in the process of oxidizing the products of combustion and decay.

Dr. Richardson has noticed that oxygen, that has been repeatedly passed over decomposing animal matter, loses its power of oxidation.

Physiological Effects of Ozone.—The physiological effects of ozone have been studied both on man and on animals. It is believed that the bracing and inspiring effect of a clear, crisp, and sparkling morning, is due in part to the great amount of ozone in the atmosphere. When it is held in combination with oxygen or common air, it acts much like oxygen, but more powerfully. It affects the pulse, the respiration, and the circulation, in various ways, according to the quantity taken, and the temperament of the individual. In this respect, it behaves like electricity. It has been thought that ozone is formed in the body from the contact of oxygen gas with the blood, and there are those who believe that it is absorbed with the ozone in the air, and is carried into the blood, where it takes part in the process of oxidation.

There is a possibility, if not indeed a probability, that electricity, in its passage through the body, generates ozone in very minute quantities, through the electrolytic and other changes that it produces, and the theory, that the beneficial effects of electrization are in part due to the ozone thus generated, has some plausibility. But on all these subjects very little is known. Experiments made in the laboratory with ozone, artificially prepared, are highly suggestive. Catarrhal symptoms and attacks, much resembling epidemic influenza, are produced by long breathing air laden with ozone. It is stated that it would be difficult to distinguish between the symp-

[1] *Vide* Fox, above quoted.

toms of influenza and the symptoms of an over-dose of ozone. Experiments on animals have shown that irritation of the mucous lining of the throat and nostrils, with febrile symptoms and congestion of the lungs, may be quickly excited by breathing air containing a large percentage of ozone. If animals are, for a long time, subjected to ozone, they perish. In their susceptibility to it, however, they vary widely. A rabbit, breathing air mingled with $\frac{1}{2000}$ of its weight in ozone, has died in two hours. Mice, breathing air about $\frac{1}{6000}$ of ozone, have died immediately. Rats are more susceptible than Guinea-pigs, and Guinea-pigs are more susceptible than rabbits. Pigeons are quite tolerant of ozone, and frogs are proof against it, provided they have abundance of water. Birds are specially tolerant of this agent, as might naturally be inferred, since, in the higher strata of the air, where they fly, ozone is more abundant than near the earth.

It has been stated that there is a relation between ozone and intermittent and remittent fevers; that rheumatism is prevalent when ozone is deficient; that, when ozone is in excess, diphtheria, quinsy, small-pox, herpes, measles, scarlatina, and other cutaneous affections, prevail; and that, during the visitation of the cattle-plague in England, ozone was below the usual standard.

There is considerable more of evidence to show that visitations of cholera are accompanied with a diminution in the atmospheric ozone.

Experiments have shown that germs, sporules, bacteria, vibriones, and small monads, with other low forms of life, are destroyed by ozone. On the accepted view that epidemic and infectious diseases are caused by spores, bacteria, etc., we can understand how a deficiency of ozone in the air may invite disease.

The only conclusions on this subject of the relation of atmospheric ozone to disease, that at present seem justifiable, are these:

1. A deficiency of ozone in the air probably has a certain relation to epidemic and chronic disease.

2. Deficiency of ozone invites disease, by debilitating the system, and thus making it less capable of contending with morbid influences.

Tests for Ozone.—Of the various tests for ozone, those which are most used are starch and *iodide of potassium*. Fox prefers the *iodized litmus* and the simple *iodide of potassium* test. The litmus-paper and the iodide of potassium must both be pure. The Swedish filtering-paper is the best. Blue litmus is purified by boiling, etc., until it is of a vinous red color. The strips of filter-paper are plunged for *one-third* of their length into a solution of neutral iodide of potassium, made by dissolving 15½ grains in 321 grains of distilled water.

These tests are exposed to the air for twelve or twenty-four hours beneath a plate. If ozone be present in the air, the iodized part becomes blue, and the non-iodized part is unchanged. Sometimes the test-paper is placed in ozone-boxes, so constructed that a current of air passes through them.

The practical bearings of atmospheric electricity and ozone are manifold:

1. Many nervous and other diseases and very many nervous sensations are perceptibly affected by changes in the quantity of electricity and ozone. Making the necessary concession that the subject of the relation of atmosphere to health is one of many complications, still we are now in a position to claim with considerable positiveness that a part of the benefit or injury that is derived from change of climate, or from the various atmospheric changes, is the result of variations in the amount of ozone and electricity. After eliminating the factors of heat and cold, which are the most obvious and best understood of all atmospheric qualities; of moisture and dryness, the potency of which is everywhere recognized; of carbonic and nitric acid; of oxygen pure and simple, there remains much that only ozone and electricity can well account for.

2. Not a few sensitive and impressible organizations experience variations of strength and debility, of vigor and *malaise*, that very well correspond to the variations in atmospheric electricity, or ozone, or both. There are thousands of people who are at their maximum of strength in the cold months of winter, who begin to decline in the spring, who, in the summer, are at their minimum, and who regularly rally during the autumn. There are those who, almost every day, pass through tides of feeling, which, if they do not mathematically correspond to the daily tides of ozone and electricity in the air, do certainly follow so closely as to make us suspect, to say the least, a certain relation between the variable states of the system and the variable states of the air. From 8 to 12 A. M. is the golden time for brain-work, as all students know; from 1 to 4 P. M. there are frequently a dullness and lassitude that make hard toil a task. Many—even those who take but a lunch in the middle of the day—are sleepy at this time, and, unless they are kept awake by business, are disposed to take a nap. The latter part of the afternoon the spirits revive, and between four and eight or nine o'clock is what might be called the silver period of the day for all mental labor. The night is given to sleep, but those who rise very early do not usually labor to so great advantage as those who defer their severest exertions until the forenoon. In these statements we but give the experience of the majority of brain-workers whose temperament is of the susceptible order, and who therefore appreciate the varying moods of the system.

The chief complication that enters into these calculations is the fact that there is least ozone and least electricity in the air when there is most heat, and that heat is of itself debilitating.

3. Irregular disturbances in the electrical condition of the atmosphere, in storms, and especially in thunder-storms, and, in our climate, northeast storms, unquestionably affect the nervous system of impressible temperaments unpleasantly, and bring on or aggravate neuralgic,

rheumatic and other pains, as well as incite mental distress and discouragement.

This fact, concerning which some have been skeptical, is as demonstrable as any general fact of the kind can be, and the opportunities for testing it among the nervous patients in this country are exceptionally abundant. Sensitive patients are oftentimes prophets of the weather; without error they can predict, even twenty-four hours beforehand, an approaching northeast storm, and, before a rising thunder-squall, they are sometimes excessively miserable. There are those who are utterly prostrated before and during a thunder-storm, thrown into vomiting and convulsions; and these spasmodic disruptions are followed by hours or days of exhaustion.[1]

Now, it is just before thunder-storms that the atmospheric electricity is so apt to be negative, and during a thunder-storm the changes in the electrical condition are very rapid.

At the Sussex County Insane Asylum, in England, the chaplain of the institution made for several years a series of experiments which showed very clearly that attacks of epilepsy and mania correspond, in a very large number of instances, to changes in electrical and other conditions of the air, and he believes that electricity is the main factor.

There is nothing strange in all this, for all naturalists know that many plants predict storms with wonderful precision hours before they appear. Man, with his exalted and complex nervous system, and especially civilized man, is far more impressible than any animal or flower.

It is not wise nor scientific nor humane to despise these subtile, storm-anticipating pains from which our patients suffer. If these are not real, nothing is real, and all existence is a delusion and a sham. They are as truly realities as small-pox, or typhoid fever, or a broken leg, and should be considered accordingly. When, therefore, the *Danbury News* man dedicates his almanac to that distinguished collaborator and weather predicter, the inflammatory rheumatism, he is as scientific as he is funny.

4. The beneficial effects of sea and mountain air on invalids may be explained in part, if not largely, by the fact that there is more ozone in the sea-air than in the land-air, and more ozone and more electricity in high than in low altitudes.

In elevated regions the air is, of course, rarer than in low-lying regions, and the quantity of oxygen inhaled must, of necessity, be less

[1] These nervous perturbations, in their various degrees, have seemed to me to be sufficiently frequent and distinctive to entitle them to be regarded as a separate disease. To this disease I have given the name *Astraphobia*. A brief description of this disease, with cases and remarks, can be found in Beard & Rockwell's "Medical and Surgical Electricity," p. 604. Strictly speaking, it comes in the category of affections allied to hysteria, like *agoraphobia* that Westphal has described. Astraphobia is more common in women than in men, though I have seen it in both sexes. The tendency to the disease appears to run in families.

than when the air is dense; but ozone and electricity both increase as we rise, and very likely this fact will explain the exhilaration and invigoration which not only consumptives but nervously exhausted patients experience on removing to the mountains. The benefit that consumptives find, by residence in elevated districts, is almost entirely of a general, stimulating tonic character, that could very well be explained by the ozone and electricity which they inhale far more abundantly than in the lowlands. The benefit derived from a change of residence from the city to the country may be, in part, similarly explained.

The influence of atmospheric electricity and ozone must always be taken into consideration in estimating the effects of medical treatment. Exacerbations of neuralgia, or rheumatic pain, or general *malaise*, or attacks of melancholia, or mania, may be excited by low atmospheric conditions, when, perchance, we suppose that the treatment we employ is working badly; and, conversely, the exhilaration that patients feel at various times should sometimes redound to the credit, not of the physician, but of the electricity or ozone in the air. There are days when all our patients seem to be depressed—all appear to be going down—and there are days when all appear to be doing well. We cannot be too cautious in attributing these changes to other factors besides the treatment we employ. We are justified in encouraging disheartened patients, who are ready to perish, with the hope that, not unlikely, they may be suffering from low atmospheric conditions that will in time correct themselves.

In order to settle some of the questions raised in this paper, I would offer these four suggestions:

I. Let daily observations in atmospheric electricity and ozone be undertaken under the patronage of the governments of different countries at all meteorological and astronomical stations. These observations, carried on for a number of years, would help to answer many important queries, and, among others, whether there is more or less of atmospheric ozone in America than in Europe. The data derived from such comparative researches would help, perhaps, to explain the peculiar and unparalleled nervousness of the people of the United States. They might help to explain the extraordinarily stimulating character of the climate of California. They might help to explain the fact that, on the Pacific coast, sunstroke is not apt to occur, even under very high temperature; while, in the East, prostration from exposure to heat not very excessive is, almost every summer, a common affection.

II. Let comparative observations be made of the atmospheric electricity and ozone of low and elevated regions. The data derived from such observations might help to explain the great benefit that consumptives and nervous patients so often find by a residence among the mountains. They might help to explain the absolute relief or cure

of autumnal catarrh or hay-fever that is found in regions lying all the way from five hundred to twenty-five hundred feet elevation above the level of the sea.[1] It has already been shown by the experiments of Becquerel on the plateau of St. Bernard, and by other observers, that there is more of atmospheric electricity as we rise above the earth, and the same has been proved also of ozone. If these results shall be confirmed by a larger induction, by observations among the Catskill and White Mountains, then we should have a potent and suggestive explanation, so far as it would go, of the powerful hygienic effect of mountain residence.

III. In times when certain epidemics are abroad, such as cholera, throat-distemper, scarlatina, etc., let observations made of the atmospheric ozone be compared with observations made at the same season and same place in other years. Of course, whatever the facts may be, we cannot rush to conclusions in this matter. If ozone be absent, may not its absence be due to the fact that it has all been consumed in deodorizing the impurities of the air, which impurities may be the cause of the epidemic?

IV. Let the physiological and therapeutic effects of ozone on the human system be studied by a large and copious induction from a wide variety of temperaments and diseases.

The criticisms that you will make on this paper I can easily foresee. You will say—and not unjustly—that in all these researches, and especially in those that relate to ozone, there is much of vagueness, little of precision—that an enormous margin yet remains wherein we may study or conjecture.

All this I admit freely and fully, but is it not so with the incipience of every science and of all forms of knowledge whatsoever? Shall we wait until our knowledge becomes absolute before we reveal it? Does it not rather become those of us who are seeking truth, as often as may be, to take account of stock of our discoveries? Is it not well, now and then, to take an inventory of our ignorance, and see how little we know? In this grand and long campaign against the kingdom of darkness we must forage on the enemy's country, and sustain ourselves for the toils of the future by the best we can get as we go along. I would be inspired by the words of Confucius: "What we know, to know that we know it; what we do not know, to know that we do not know it, that is knowledge." I would be inspired by the example of Lessing, who preferred to seek after truth, than to find it.

[1] Blakeley, in his work on "Hay Fever," has shown by experiments that more spores and pollen, by far, are found a thousand feet or so above the earth than at the ordinary breathing level. These experiments would indicate that the cure of this disease, by removel to elevated regions, must at least be explained in some other way than by the theory that the mountain air contains less irritating substances. This subject I hope to be able to investigate at the White Mountains during the coming summer.

THE GREAT CEMETERY IN COLORADO.

By REV. SAMUEL LOCKWOOD, Ph. D.

IN the composition of his ecclesiastical history, an erudite historian chaptered the narrative into centuries. Perhaps for his subject these divisions were sufficiently generous. Still, as measurements of time they were but puny epochs; and yet they were vast enough for the treatment of that ephemeral worker, man. But He, "who worketh hitherto"—who, as the true Earth's Biographer, wrote on the stony rocks—made his divisions THE AGES! Indeed, *can* those epochs be reduced to years? What a scope must the record of his doings have with whom a thousand years are as a day! Accepting these life-cycles with a significance so grand, we reverently look into this great volume. Its opening chapter is the Cambrian age. But—amazing!—the stony laminæ that make up its leaves are scarcely less than *one hundred thousand feet in thickness!* It was a time of dreary wildness, and its primeval life-forms were few, and huge rock-masses were tilted up from that sea, and worn down for the bed of the waters. Next came the Silurian age, singing the weird music of its one world-encircling sea. Its forms of life were innumerable. Then flourished the Brachiopods, or shell-bearing worms, and Mollusca, Crustacea, corals, and a few fishes. Then comes the Devonian age. Now it is that what seemed a monotonous, watery waste becomes as a weary Sahara, with many a green-fringed oasis cheered. The late universal sea is dotted with low-lying islands. Very beautiful, though lowly in rank, and not over-luxuriant in numbers, were the plant-forms that fringed those shores. Then the fishes composed the nobility of life. Their patterns were grotesque; and they were clad in mighty plate-armor, massive osseous tiles, of quaintly sculpture. It was an armature that spoke unmistakably of crimson conflicts; for, in sooth, these were not "piping times of peace." Next came the Carboniferous age. The area of land is greatly increased; and it is beautified with a new and amazingly luxuriant vegetation. In this plant *régime* the queenliest being is the arborescent fern. And this luxuriant vegetation stores up the solar force, a rich legacy for the far-off but "coming man." At this time a few air-breathers occupy the land. With frog-like affinities, they are of very low reptilian rank.

Passing the Permian and the Jurassic, next comes the Cretaceous age, with the culmination of that reptilian race of monsters of amazing size and most singular aspects. It was, indeed, the companionship of "Beauty and the Beast;" for at this time, also, the nautilus, and the ammonite, those peerless structures of the molluscan life, reveled in beauty and vastness of numbers. But a sad change came, and the gay nautilus tribe was reduced to the merest representation

in the animate scale; while the star of the resplendent ammonite went down in utter death. And there must have been peculiar conditions of both land and sea, in that Cretaceous day, or those strange reptiles of Brobdingnagian altitude could not walk on the land; nor could their aquatic congeners of cetacean bulk, the huge sea-reptiles, move in their briny homes; so with the Ammonites, and the great selachian fishes. But these—the beauties and the monsters—all died, for there came in new conditions of the land, the sea, and the air.

And with these new conditions came the Eocene age, or dawn of the Tertiary epoch of Earth's lifetime. So decided was this physical change, that all things were ready for its reception of a new race of living creatures. The very surface was newly and lavishly garnished, like a table awaiting the expected guests. And the atmosphere had a balmier vigor, a sort of climatal ripeness, like the aroma of an autumnal orchard whose fruit has matured. Now came the true grasses, and the grains; and the Rosaceæ plants with the strawberry, blackberry, apple, cherry, and plum, etc. And Nature's guests arrived, and entered upon the enjoyment of an unrestrained existence in her grand domain. And they were welcome guests; for leading the train came the (as yet) noblest of her begettings, beings of true mammalian rank. They were of new forms and new appetencies. Some were *petite* in size, and some were of more than leviathan proportions, and many were *bizarre* in form; and all were diverse from every thing that had lived before, or that should ever come after. And so each in its own way, as disposition or convenience prompted, enjoyed life. Some preferred the banks of the great rivers, others the grassy meads of the green valleys, and others the sides of the densely-wooded hills. And the timid rodents hid themselves in their burrows at the roar of the carnivores, while both were startled by the beastly bellowing of the great terrestrial behemoths. And these beings, at least some of them, have left their relics in the far West, in places where, until lately, only the red-man had trod.

The geological age just mentioned is called the Tertiary. It was for the first time with true significance sectioned off by Sir Charles Lyell. This learned geologist noticed that this age opened with animal life more like that of the present than any thing that had been before, and that in respect to the molluscs there were many forms identical with existing shells; and he noticed that, as we ascended in this age, the percentage of forms thus similar very rapidly increased. He, therefore, named the bottom section the Eocene, meaning the dawn; and the middle section the Miocene, meaning less of its dawn, that is, farther on in the day; and the highest section he called the Pliocene, meaning still more advanced. To these has been added another, namely, the Pleistocene.

There are three American names which, in respect to the most recent results in vertebrate paleontology, deservedly stand as its

great lights—Prof. Joseph Leidy, Prof. E. D. Cope, and Prof. O. C. Marsh. The last two, with an enthusiasm that has triumphed over great difficulties, have especially produced startling results in their individual explorations of the great graveyards of the ancient dead in our Western Territories. Of the labors of Prof. Cope, as conducted under government auspices, it is proposed here to offer a few results. We shall simply give some details of his work done last summer, as the vertebrate paleontologist in behalf of Prof. F. V. Haydon's "Seventh Annual Report of the United States Geological Survey of the Territories." Prof. Cope found himself literally in a crowded cemetery of a quadrupedal race long extinct.

The list which now immediately follows is limited almost exclusively to the Miocene fossils of "the Bad Lands" of Colorado. It tells a marvelous story of rich and formidable fauna that existed on our virgin continent in that Middle-Tertiary age. The Rodents, or gnawing animals, were well represented. Five genera seem to be established, embracing eighteen species. The predecessors of the squirrels were there. One, named *Paramys*, was a little larger than our chickaree. One little creature, called *Heliscomys*, had four teat-like cusps on the crown of each molar in the lower jaw. This was the tiniest thing of them all, and stood, probably, among the Miocene rodents, as the common mouse does among the gnawers of to-day. If, indeed, Heliscomys be the ancestral mouse, our *Mus musculus* has a very ancient pedigree. The rabbits were represented by the genus *Palæologus*.

There are eleven species of Insectivora, arranged under five genera, with the names *Domnina*, *Embasis*, *Miothen*, *Herpetotherium*, and *Isacis*. Except the last one, all these are allied to the mole. They had doubtless the same burrowing habits and food appetencies as the Talpa tribe that to-day follows and annoys the gardener at his work. It is an item gained of real knowledge as respects animal habits, to learn that the earthworms and the subterranean larval insects were kept in check in the same manner then as now. And, if these are the predecessors of the Talpa race, we would like to know if the primitive stock were as clever engineers at constructing subterranean earthworks, for the mole to-day is a genius in that line. There are six species in the list, and they differ quite a good deal in size; and would seem also to differ in some more important aspects, as the name of the *Herpetotherium* signifies the "crawling beast." It is worthy of remark that these ancient moles, like the modern, were very small animals. Necessarily, then, the fossil bones must have been very minute. They are, however, preserved with wonderful perfection.

As to that other insect-eater, *Isacis*, it represented the existing hedgehog, as shown by its anatomical structure. And as snakes abounded then, probably, like its congeners now, it made many a meal of them, utterly regardless even of those poison fangs, if such they

had. But the great carnivores had a covetous eye on *Isacis*, when it probably rolled itself up in its bristling armature, and, in full consciousness of a *noli me tangere* security, invited its enemy "to kick against the pricks"—in fact, to do his worst. And, doubtless, many a hungry feline, after recklessly accepting the invitation, got very badly worsted. As we shall see, there were little keen-toothed tigers then; but their acquaintance with *Isacis* always ended in disgust, as futile must have been each effort to get a dinner of hedgehog raw. Similar is the experience of our Adirondack catamounts in their attempts on the Canada porcupine. These fierce cats sometimes perish terribly from inflammation caused by the spines of the porcupine, which they are unable to extract.

The carnivorous animals were largely represented. Prof. Cope gives at least ten species. There are five genera of felines, or cats. One of these is quite small, being only half as large as the domestic species; another one, called *Stibarus*, for a cat, seems to have been a rather stout animal. Of these felidæ there are three genera which possessed remarkable saw-edged teeth, painfully suggestive of the carcharodont sharks. Accordingly, one of these is named *Daptophilus squalidens*, which, in plain though somewhat clumsy English, means the "shark-like-devouring lover." We are not from this to think of the grand Mogul, who loved his wives so well that he carved them up; but in metaphysical parlance the phrase must be taken subjectively, as of that absorbing passion where the subject loves to take his victim in—that is to say—one who is as voracious as a shark.

Another of these sabre-toothed tigers had its teeth very strong as well as sharp. "The incisors are very stout, and exhibit slightly curved conic crowns, with a serrulate edge on the inner face." These teeth are more suggestive of the trenchant cutlass than the fine sabre. Though not larger than the existing Canada lynx found in the Adirondack Mountains, this terrible tiger well deserves its fearful name—*Machirodus oreodontis*—the "mountain-like sword-toothed." Another of these carnivores, a new genus, is called *Tomarctus*. It had some relationship to the canines, but, if a dog, it was of very large size, as it probably equaled in this respect our native black bear. There were, however, true dogs then; and some of their remains were secured in the expedition. Their bones, associated with those of the rodents and insectivora, are quite numerous. One species, called Lippincott's *Canis*, was about the size of the coyote, or wolf of the plains. Other species obtained were larger than this; and others again were smaller. A Pliocene mastodon is mentioned, which carries the true Proboscidia far back in time. It is named *Mastodon proavus*, the specific name meaning "before one's grandfather."

Among these Colorado fossils, the ungulates, or hoofed animals, are very prominent. In the advanced classifications of the mammals, the ungulates are divided into the *Perissodactyles*, or those ungulates which

have an uneven number of toes—as the horse with one toe, and the rhinoceros with three—and the *Artiodactyles*, or the ungulates with an even number of toes—as the hippopotamus with four toes, and the hog with its two functional toes. Now, of these fossil ungulates it is remarkable that the expedition has brought home from the Miocene twenty Perissodactyles, and the same number of Artiodactyles; and from the Pliocene nine Perissodactyles, of which four are new, and six Artiodactyles, of which three are new; thus making fifty-three ungulates. Of these there are several horses, and all of them, including *Anchitherium* and *Protohippus*, have three toes to each foot. These cloven-footed beasts were some of them strange, comprehensive types, possessing in the same individual structural resemblances to both swine and deer; "like the latter, these had no horns; they were about as large as sheep. Others were about the size of gray squirrels, being the smallest of this class of animals ever discovered" (*American Naturalist*). Indeed, an important paleontological result has been Prof. Cope's determination of the correct relationship of five species (three new, and one new genus, *Hypertragulus*) to the musk family. The general reader should perhaps be told that the order *Ungulata*, or hoofed quadrupeds, really absorbs three of the orders in the older classifications, namely, the *Pachydermata*, the *Solidungula*, and the *Ruminantia*. This mentioned, we would say, with no irreverence, that in the Colorado fauna of Tertiary times Nature seemed to indulge, as respects the animals of this order, in the most eccentric extremes of structure, both as to form and size; for some of these hoof-footed ones are scarcely larger than a squirrel, while some are as large as the elephant; and there is a seeming oddity of structure. Though a fact before every one's eyes, yet many are not aware of its existence, viz., that the ox and cow have no teeth in the front part of the upper jaw. When this animal grazes, the tongue makes a curl, or twist, and pulls in the grass, then the lower front teeth are made to meet the firm pad of the front part of the upper jaw, and the grass is then severed. Such is the mode common to the ruminating animals, that is, those which chew the cud. Now, in the natural group Ruminantia, comes a sub-group, the *Camelidæ*, which includes the camels and the llamas. The dentition of these animals is very aberrant. The upper incisors are not entirely wanting, "there being two canine-like upper incisors, and upper canines as well." In the Pliocene strata of Colorado are found the remains of two species of camels, of enormous size, and which, strange to say, are furnished with *complete upper incisors*, or front-teeth. These ancient camels, then, did not graze like the ox, but like the horse.

And, among these hoofed creatures, the *Rhinocerotidæ* are represented by three genera. Two of them belong to the Miocene, and the third, the last discovered, to the Pliocene. This is the new genus *Aphelops*, a monster of immense proportions. The other two genera

are *Hyracodon*, and *Aceratherium*. It is remarkable that Prof. Cope has made out seven species of these fossil *Rhinocerotidæ*, which, until the recent discovery of the living hairy-eared rhinoceros (*R. casiotis*) at Chittagong, the northern extremity of the Bay of Bengal, was the precise number of the living species known. It amounts to a certainty, then, that our great Western Tertiary was much richer in species, and immensely richer in individuals of these enormous beasts, than is the whole living fauna of the entire world to-day. And what singular relationships did these *Rhinocerotidæ* hold in those Tertiary times! For there were other animals that held structural alliances with them. One of these the professor has named *Miobasileus*, the Miocene King. This the learned man doubtless did in respectful deference to a notable personage that had died some time before. It was in fact in the Eocene reign that this individual flourished. So the professor refers to him as *Eobasileus;* while another *savant*, deep in the lore of those times, contends that it belongs to a different family. That its place is in the new order *Dinocerata* seems undisputed. What the true dynasty was is not for "the likes of us to say." Besides, we would shudder at any personal attempt to wade this paleontological marsh; and would frankly confess a lack of strength wherewithal to cope with a subject so grave as the one which has grown out of these exhumed remains. But, whatever ground there may be as to specific identity or distinction, on these words of Prof. Cope, in his diagnosis of the genus *Eobasileus*, there is full accord: It "indicates a remarkable combination of structure not before known to naturalists. The gigantic size of the typical species (*E. cornutus*) adds to its interest, and shows it to have been the monarch of the remarkable fauna disclosed by recent researches in Wyoming." The genus is "established on remains of five individuals of the average size of the *Mastodon Ohioticus*. . . . From the manner of the occurrence of the relics, this animal probably went in families, or herds," as do the existing elephants.

But it is time to return to his Miocene majesty. It was even with Eobasileus much as it has been with other ancient monarchs. He had a wicked way of lifting up his horn. Nay, he lifted them twain; for, owing to an ophthalmic difficulty which seems to have been constitutional—like some modern patriarch, who, when he wants to look upon his household with aspect of authority, doth push his spectacles high up on his head—so this king of the beasts! when he wished to feel,

> "I am monarch of all I survey;
> My right (who shall dare) to dispute?"—

that is, when he desired to look up and around, like a king, with brow austere—he tossed those spectacular horns on high, and backward. The fact was, his supremacy lay in his horns. And herein were some disadvantages. "Uneasy is the head that wears a crown." Each

horn was a magnificent affair. But, as sometimes happens with the leading ornament, it was a little awkward in the setting. It was fixed right over the eye! Still, queer as this was, it had its uses. Hereby was achieved a huge bony arch, or cavern, for the protection of the kingly orb beneath—an important provision in case some sturdy old recalcitrant should stand in the way when his majesty went out on a regulation inspection of the royal domain; for, unlike some of his post-relations in Africa and Asia, who are content to take one horn at a time with their compeers, he never took less than two at a bout. In fact, the *Rhinocerotidæ* of the Tertiary age had their horns in pairs; and without doubt they were used in many a pell-mell fight—contests that likely had but little thinking as to the method of the conflict. From this arrangement of the horns in pairs on these creatures, so nearly related to the rhinoceros, the professor with a keen sagacity claims to disprove the statement that horns in pairs show relationship to the ruminants. His own words are: "They present no special marks of affinity to the artiodactyles, and show that the paired horns of the *Eobasileidæ* have no significance in the same direction."

A luminous body, if unobstructed, strews its rays in all directions. And a scientific fact or principle, could our eyes follow the emanations, would be found illuming many if not all other facts in science. It was but lately that the above generalization was reached, when it came forth full-blown from the working out of the new genus *Symborodon*. Of these very remarkable animals the professor gives us six or seven species. And strange beings, even among their contemporaries, must the *Symborodontes* have been. There was *Symborodon bucco*—the last word meaning "the cheeky"—and the fellow had "plenty of cheek." It was certainly so anatomically, and "we" are not speaking metaphorically now. The cheek-bones were enormously developed, so much so that they formed immense osseous masses on each side of his head. Indeed, a blow on the side of his caput would have been simply a capital joke; for how could so unimpressible a skull ever have seen the point? And this same individual comported himself with a ludicrously lofty air, for his eyes were set almost vertically in his head. Perhaps it was the Miocene fashion in the upper ranks to look for something to come down, unlike our Micawber mode of waiting for something to turn up. And this being was nearly as large as an adult elephant. As to what, and how much was his intellectual endowment, we know not. We don't think he was very sharp. But we had forgotten to add this attribute—he had two horns, and they were flat.

Perhaps the Caliban of those strange creatures was *Symborodon altirostris;* not that he was a dwarf among his compeers, for, though not the largest, he was an individual of great weight in his own day. Nor was it that he had a "forehead villainously low;" but because,

on the contrary, he carried a forehead most rascally high, and surmounted by a pair of horns that were murderously straight and sharp. Prof. Cope speaks of this species as the most formidably armed, and as presenting a most *outré* appearance in life. It can be scarcely doubted that his eminence was held in great consideration by the Symborodon people, and that they gave him a wide berth when he went out to take a constitutional.

Another of these beasts enjoys the name of *Symborodon trigonocerus*. His horns were three-sided, like a bayonet. To be sure, they were short, and rolled outward, which made them harmless in comparison with the former. This was a large beast, but not so large as *Symborodon bucco*.

The smallest of these creatures was *Symborodon acer*. Poor little fellow! How they must have looked down upon him! He was not as big as the Indian rhinoceros. But he had his own revenge for this condition of sub-mediocrity. His horns were very long and round. Indeed, he could boast of this accomplishment. And it was notable that he always kept the fact plainly before his eyes. He had the longest horns of them all, and carried them one on each side of his nasal extremity; and it was generally understood that, when *Symborodon acer* turned up his nose, he meant mischief.

Speaking of the above group, says Prof. Cope: "Thus it is evident that *Symborodon* is a true perissodactyle, allied to the *Rhinocerida*." To have discovered and worked out this one group alone should give a man glory enough for one lifetime. And yet we are far from having exhausted the list of ungulates. There are *Oreodon*, two species; *Poëbrotherium*, two species; *Septomeryx*, and many others, all cloven-footed beasts; and about these we have said nothing.

But there is still one mammal to be mentioned; and thereby hangs a tail, for it is a monkey. It is a little fellow, but with a big name you may depend, as witness—*Menotherium lemurinum*. Unless his name mislead, he was a nimble beast, and, with the lemur instinct, a night-prowler at that; for his anatomy connects him with the Lemurs, the lowest of the monkeys, and, if we mistake not, there were Nasuan relations also,[1] as with those fossil monkeys obtained by Cope, in the Eocene strata in the Bridger beds on Black's Fork, Wyoming.

Thus much for these new mammals, so remarkable in numbers and character. But the reptiles were largely represented also; for there were serpents, lizards, and turtles, found in those Colorado beds. Of the snakes, one, a *Neurodromicus*, was as large as the black snake;

[1] Both Profs. Marsh and Cope have collected fossil quadrumana from these great Western graveyards. For a remarkable confirmation thus afforded of a generalization made by the present writer, see article "Coati-Mundi," POPULAR SCIENCE MONTHLY, December, 1872, page 136, in connection with "Fossil Monkeys," in idem for August, 1873, page 519. It is worthy of remark, also, that recent anatomical studies of the Lemurs, by the younger Milne Edwards, afford additional confirmation.

another, a *Calamagras*, was the size of our water-snake; while another, of the same genus, was about as large as a garter-snake. Of these ophidians, all the species and three of the genera are new to science. One thing is observable in Nature—the provision made for sustaining the proper balance, by keeping in check that which might become in excess. It is plain that the moles were very numerous. But these and their congeners were not relished by the mammalian carnivores. The bad smell of the shrew prevents the cat from eating it. Probably the snakes were less dainty, and herein, perhaps, lay their utility in the animal economy. It might seem that Prof. Cope had assigned to the ophidia a similar task, as he names one species *Aphelopis talpivorus*, which simply means the mole-eating Aphelopis.

The Lacertilia, or lizards, furnish some interesting traits. Prof. Cope gives six characteristically separated genera, and all are new. *Exostinus* and *Peltosaurus* were lizards with bony shields, and symmetrical bony tubercles on the head. Here comes in an interesting fact for science, namely, that this is the first time that the ophidia and lizards have been found in the Miocene strata of America.

The turtles are represented by several species, which, although new, present no features of popular interest.

We will now give some facts pertaining to this work of the Geologists in the Territories.

There were really three expeditions made last summer, one to the "Bad Lands" of Colorado, one to the "Bad Lands" of Wyoming, and the third to the Cretaceous formation of Kansas.

As respects the "Bad Lands" of Colorado: three distinct geological formations were found superimposed, or lying in sequence. First, at the base was a series of strata containing fossil wood. This was Cretaceous, and was known as the "Lignite Division." Next came strata known as the "White River Division." This was Miocene. The next was the "Loup Fork Division," and this was Pliocene. Of course, speaking geologically, this was top of all.

In the Pliocene the fossils found were twenty-four species, of which ten were new to science. They embraced four carnivora, one proboscidian, a mammoth, seventeen ungulates, of which two were great camels. With these ungulates were a number of Pliocene horses. Two interesting facts were obtained: one, that all the horses had three toes to one foot, and the other that the camels had full sets of incisor teeth in both jaws. In this formation was found the large rhinoceros, *Aphelops*.

From the Miocene were obtained: rodents, eighteen species; insectivora, eleven; carnivora, ten; perissodactyles, twenty; artiodactyles, twenty—thus making forty ungulates; quadrumana, one; lacertilia, or lizards, seven; ophidia, five; turtles, five. Probably the following may be set down as the chief results growing out of the

Miocene harvest: The first is the discovery of monkey remains; the discovery of snakes and lizards in American Miocene, and related to the corresponding genera of the Eocene of Wyoming Territory; the settlement of the correct relations of five species, of which three species and one genus, *Hypertragulus*, were new, the relation being to *Moschidæ*, or the musk-deer family; the determination of the genus *Symborodon*, as allied to the rhinoceros on the one side, and to *Eobasileus* on the other; the discovery of numerous insectivora, allied to the mole. Such is an epitome of the results of the summer's work in Colorado.

In Wyoming Territory occurred the fact so highly important to strategraphical geology—the discovery of the Bridger strata of fossils just above the coal at Evanston. This fixed the age of the deposit geologically, a fact of primary importance to the geologist; the discovery of the new genus, *Anchænodon*, an animal near to the swine animals of the genus *Elotherium*, also allied to *Anthracotherium* of Europe; the discovery of the large animal *A. insolens;* also of long canine tusks of *Bathmodon.*

In Kansas numerous fishes and reptiles were discovered. One of these was the saurodont (lizard-toothed) fish, *Portheus gladius.* This creature was terrible. He had a pectoral spine which he could elevate at pleasure, and it was four feet long.

Thus we have for a summer's work, by Prof. Cope, not less than 150 species of vertebrate animals alone, of which 100 are new. This makes no account of the collections of the invertebrates. "There is a view generally entertained by naturalists and geologists, that genera and species of animals and plants are greatly more numerous at the present age of the world than in any previous geological period. This seems to me an entire misconception of the character and diversity of the fossils which have been discovered in the different geological formations." So wrote the lamented Agassiz just twenty years ago. Surely there can be no uncertain opinion on that subject now. "Prof. Cope has obtained from the ancient sea and lake deposits of Kansas, Colorado, Wyoming, Idaho, etc., about 350 species of vertebrated animals, of which he has made known to science for the first time more than 200 species!"

Profoundly and alike wonderful, then, to philosopher and naturalist is this story of the irrevocable extinction of entire races of animals. And the same earth-area of that wellnigh fabulous land has seen even greater things than these; for, both before and since the historic age began, it has beheld the passing away, into the darkest dimness of tradition, whole tribes and languages of men.

SCIENCE, EDUCATION, AND ARISTOCRACY.[1]

THERE could be no doubt that, in the age in which it was their lot to live, the tendency of education ran toward science and abstract science, and every man who was interested in the fortunes of his generation would naturally ask himself the question what the effect of such scientific teaching was likely to be, what it would be still more likely to produce, if it rose to absolute predominance, and whether it would raise or lower, soften or harden, those upon whom it was brought to bear. As he said before, no reasonable man could doubt that the tendency of the age was to make scientific teaching the predominant study. The greatest of philosophical writers would admit that was so. That which followed the main teaching of former times —the great arts of sculpture, painting, writing, oratory, and the like— all comparatively sank before the abstract science of the present day. Compare for one moment the range of teaching in the middle ages with the present circles of learning. In the tenth century Pope Gebert was said to embrace within himself all the knowledge of the time; but let any one contrast his attainments, great as they were, with the correlation of arts now practised, and the enlarged field over which modern science ranged. There was undoubtedly a vast difference between the two states of things. When they looked at the present state of scientific education they might fairly distinguish three different classes of persons to whom it might be applied. First, there were those like the late Mr. Brassey, great captains of labor, who led men not only over Europe, but over every quarter of the globe, and changed the whole face of the earth by their vast engineering power and skill. Secondly, there were those among them at the present day who saw only through the eyes of material philosophy, who accepted that material philosophy and scientific teaching as their surest and safest standard and guide, who reduced most things to it and judged most things by it, but whose minds were nevertheless open to other considerations, and who did not feel that it was the sole and exclusive standard of their lives. To both those classes what he was about to say did not apply. There was, however, a third class who were tempted to reduce every thing to the one standard of science—who knew no other law and applied no other rule, not only to science itself, but to all the other conditions of life and action. To such a class, though he alluded to no one in particular, his observations would, he thought, apply. When science was pushed to that extreme its professors would not be the best rulers for mankind, and he, for one, should regret to see the affairs of men regulated solely by such a

[1] Extract from an address of Lord Carnarvon before the London Birkbeck Institution, with comments thereupon by "J. H. L.," of the *London Examiner*.

standard as they would apply. If such views as they held were pushed to an extreme, he could scarcely imagine a Pharisee more arrogant, a Sadducee more self-opinioned, a fanatical monk of the middle ages more intolerant than they who practised them were likely to be.

He might be asked the reason for all this. Some might say it was a reaction from the extreme dogmatism of past times; and it was undoubtedly true, as every careful student of history would admit, that there had been an excess of dogmatism in former days. Theology, for instance, had encroached upon the fair and reasonable domain of science, had sometimes thrown obstacles in its way, and had subordinated science to most mistaken and unreasonable interpretations of Scripture. On the other hand, there was now a risk that science might possibly encroach a little on the domain of theology. At all events, it seemed to him there were reasons why what he had just now said should be the case. In the first place, unlike other studies, it must always be remembered that the conclusions of abstract science were demonstrable. Those who dealt in them were so satisfied of their certainty that they could not accept any conjecture or doubt on the point. There were branches of science in which that was perfectly true, as in the case of mathematics, where in certain propositions no reasonable man, applying the ordinary laws of thought, could doubt certain results—such, for instance, as that two and two were four. There were other branches to which that did not equally apply, but one thing was certain—that those who would carry that frame of mind into the complex relations of human life, into political and social philosophy, and into all the relations which affect men one toward another, were applying a standard which was wholly impracticable, and which would ultimately lead to mere confusion.

In the next place, he would again say that, unlike other studies, mere hard, abstract science did divorce itself from literature, and almost repudiated religion; and he thought no man who looked back over the varied course not only of the middle age history, but of the whole history of the world and of mankind, could doubt that, whatever might have been their shortcomings, defects, and excesses, men owed to the influence of literature and religion far more than they could express, far more than they were likely to admit, and far more than he could attempt to describe on that occasion. At all events, they had exercised the softest and most refining influence upon mankind. Undesirable as it was for men that any one intellectual power, so to speak, should exert an exclusive rule over them, or enjoy a monopoly of authority, he freely admitted that he would prefer the authority of literature and the arts to that of mere pure, hard, abstract science. Art had been well termed "the handmaid of religion," and literature had formed a republic of letters; and their rule, though variable, unjust, and even unequal, would not be the grinding, rigid

despotism, and would not impose that yoke, which hard, abstract science would.

He might be asked why he entertained that great dread of scientific men as the ultimate rulers of a community. He was not blind to their great merits, or to the vast intellectual power which they wielded daily more and more, and he was neither out of sympathy with them nor were their subjects uncongenial; but, as he dreaded a monopoly of power by any one class, so he especially dreaded it in their hands. He believed that abstract science, so to speak, was very often devoid of the milk of human kindness and sympathy, and he would quote an illustration of what he meant from one of the most remarkable and touching books he had ever read—"The Autobiography of John Stuart Mill." He should be sorry to take Mr. Mill as a representative of hard, abstract science, for throughout his nature there ran veins of feeling softer and more tender than he was willing himself to allow. But he quoted that book for the moment as one of the fairest illustrations of the action of the philosophical mind in these matters. Those who had read it would remember how carefully Mr. Mill, partly under the influence of his father and partly through his self-education, endeavored not merely to suppress but to trample down and to crush out every thing approaching to feeling in his nature. In that respect he was utterly unlike Bishop Butler, who held that the feelings were of the best and most indispensable parts of the human system. He remembered that so far did Mr. Mill carry his theory into practice that he took the opportunity of stating that in his opinion it would be indefensible for an educated man to enter the same room as an uneducated man except he were the apostle of some creed that he was about to propagate. He could conceive nothing more selfish or more subversive of all the principles on which all society existed than that doctrine. He remembered the story of a conversation related by Southey between Sir Humphrey Davy and Faraday, in which the latter, then a young man, told Davy that he was anxious to join in the pursuits of science because its professors were more likely than others to be of a liberal cast of mind. Davy smiled mournfully, and replied that, whatever science might be, it did not of itself convey that liberality of mind which Faraday so fondly imagined for it. Lord Carnarvon objected to the application of those rules, which naturally and rightly governed abstract science, to legislation, morals, social life—in fact, to every thing which concerned the existence of man. Some would remember that in the years 1848 and 1849, when all the Continent was disturbed, when thrones were laid in the dust and kingdoms shaken, a group of all the most eminent philosophers of the time met in Frankfort to review the condition of affairs, and they would recollect the very unsatisfactory conclusions at which they arrived.

Auguste Comte, whose name was so great abroad, founded a philosophy which contemplated the transfer of all those powers hitherto

exercised by priests and sacerdotal parties to the philosophical class, but he was obliged, in constructing his theory, to form a sort of corporate hierarchy and invest them with the very powers taken from those whom he had so strongly denounced. In so doing, as Mill in an early book had said, he had furnished "a monumental warning" to those who dealt with such matters. Science itself, however speculative a range it might take, could not naturally be pregnant with the tender and softer feelings unless it was coupled with altogether different principles, which would enable it to be applied to the affairs of mankind. Look back for a moment on the different forms which science had sometimes taken. In the middle ages "Italian cruelty" was a proverb. Italy, which could then count more men of science than the rest of Europe, was not hindered on that account from also claiming a monopoly of cruelty. Chaucer threw out the same sneer at scientific men of his day, and during that time there arose that curious and mysterious combination of poisoners in Europe who united science with no tenderness of heart. Science, therefore, he thought, was no safeguard or guarantee of itself for tenderness and affection, but when joined with something higher in the human system it would call into play all the highest qualities of the mind, and assert an intellectual and moral domain in which the greatest of men could serve.

THE speech delivered on December 6, 1873, by the Earl of Carnarvon, at the Birkbeck Institution, is a very significant indication of the progress of public opinion, at all events in one direction, during the last half-century. Fifty years have passed away since the late Dr. Birkbeck, aided by a small band of the ultra-Radicals of his day, founded the Mechanics' Institute in Southampton Buildings. The work was begun and carried on amid the howls, and execrations, and sinister prophecies of those "upper" classes whose lordly representative came down, a week ago, to smile his approval upon its success, and to hallow it with a patrician benediction. No words were too hard for the revolutionist and heretic whose profanity had reached such a pitch that he dared to encourage working-men to learn something besides the Church Catechism. Here was a man—and, strange to say, a gentleman—acting on the assumption that the horny-handed and ill-smelling laborer had a mind which ought to be cultivated, had a life which ought to be lived for some other purpose than that of making his "betters" comfortable. Worse still, he did not hold it as a theory to be dilated upon on Sundays from a pulpit, and to be realized on the other side of the grave; but, to the horror of the Newdegates and Tomnoddies of 1823, he actually went and set up an institution in which science—"hard, abstract science"—might be taught to the "great unwashed." No wonder that a noble-minded aristocracy held

their faces half averted and their eyes half closed at the contemplation of such enormity. No wonder that our established clergy raised their smoothly-shaven chins in meek abhorrence of such impiety, and displayed their white neckcloths, the emblems of the pure sentiments which surged beneath. Perhaps the strangest thing in the whole of this history—and it shows that there must be something radically wrong in the constitution of the universe—is that this wicked enterprise weathered the storm, and that the parent institution is by far the most important educational establishment for adults in the metropolis, while its progeny may be found thriving in almost every provincial town of any size throughout Great Britain. Tell it not in Gath, publish it not in the streets of Askelon. Here is an educational institution which, without any help from nobleman or priest—save that which they conferred by staying away—is not only succeeding, but getting over the "religious" difficulty by leaving theology to be taught elsewhere, and solving the problem of female education by simply opening its doors on equal terms to men and women. This "godless" college is now educating 2,712 students of both sexes; its curriculum is as wide and its teaching as thorough as that of any institution with which we are acquainted; and so completely have the bogies which frighten the outside educational world been exorcised, that even a thought of them never seems to cross the minds of the students who, after their day's toil, come down to instruct themselves in literature, science, and art, and to take part in the management of their *alma mater*.

How was it that Lord Carnarvon cast his benignant smile on such an institution? Times, it is said, change; and we change with them. Has the leopard of obscurantism, then, changed his spots? His lordship's speech furnishes a complete answer to this. It shows that the Tory oligarchs are as thoroughly opposed as ever they were to the work of education. They are acting over again the old fable of the sun and the wind. Force has failed, and they are trying to gain the same end by persuasion. The difference is purely one of engineering. They have tried the granite wall of direct resistance only to find it shattered by the heavy artillery of the democracy, and their hope is now in the yielding earthwork of patronage. Lord Carnarvon and his compeers love popular education as the Duc de Broglie loves parliamentary government. They will resist giving it at all as long as possible; and, when this cannot be done, they will push themselves to the front and undertake the supply of the article, taking care to do as fraudulent tradesmen do with their milk, skimming as much of the cream off, and adding as much water, as they can without being detected.

The whole gist of Lord Carnarvon's address was an attack on scientific education. Not that he objects to science if kept within proper bounds. He does not find fault with "those like the late Mr.

Brassey, great captains of labor, who led men not only over Europe, but over every quarter of the globe, and changed the whole face of the earth by their vast engineering power and skill." Not being a "materialist," this is the kind of science his lordship likes best. Next, there is a class of scientific men who accept "material philosophy and scientific teaching as their surest and safest standard and guide . . . . but whose minds were nevertheless open to other considerations, and who did not feel it was the sole and exclusive standard of their lives." As science tempered by "other considerations" would be acceptable to Pope Pius himself, we need not be surprised that to this Lord Carnarvon has no objection. It is for a third class of scientific men he reserves his denunciation. There is, it appears, a class—if, indeed, so small a body of men can be called a class—who carry the scientific frame of mind "into the complex relations of human life, into politics and social philosophy, and into all the relations which affect men toward one another." The influence of this little class is growing, Lord Carnarvon tells us; and we are convinced that he is right. Now, at this he is very much terrified. If only those naughty scientific men would keep to engineering and physics, his lordship would not care; but what he objects to is "the application of those rules, which naturally and rightly govern abstract science, to legislation, morals, social life." In other words, scientific men may settle the distance of the sun from the earth at what figure they like, and they may build bridges and construct railroads; but, if they apply the same logical processes which they have found serve them so well in the material world to the solution of social and political problems, this is really too much for patrician nerves. There is a hardness about the scientific method which Lord Carnarvon does not like. If it were not for this diabolical device, we might come to any conclusions on social matters which fit in with our predilections or interests; but, with the "grinding, rigid despotism" of logic, this is impossible. All that manly independence of our premisses which occasionally characterizes our conclusions on political matters would be gone forever, and "one intellectual power" would "exert an exclusive rule over" us.

Lord Carnarvon did not content himself with a mere depreciation of social and political science, but attempted to point out its shortcomings. It is, he thinks, "devoid of the milk of human kindness." This is quite true, and a much wider truth than stated. It is as true of the multiplication-table as of scientific politics. But, when Lord Carnarvon, showing a little of that individual freedom which he despairs of keeping, argues that, because science is "no safeguard or guarantee of itself for tenderness and affection," therefore, those who are thoroughly imbued with the scientific spirit trample on and despise affection and tenderness for their fellow-creatures, he is appealing to one of the most foolish of prejudices in support of one of the most disingenuous of arguments. The love of truth, for its own sake,

which is popularly confounded with "hardness," is in no way bound up with want of sympathy or kindness; but people are so used to carry their sentiments into the decision of questions of fact, that when they find any one does not do so, they conclude that he is without feeling. Nothing could be a clearer proof of this than the instance brought forward by Lord Carnarvon. Mr. Mill, he says, "endeavored not merely to suppress but to trample down and to crush out every thing approaching to feeling in his nature." That this should be said of the most tender of husbands, the kindest of friends, the man whose sympathies were as wide as the animal creation, whose depth of feeling was such that there was not a noble or a beautiful thing in Nature but it mirrored itself on his heart—is convincing evidence of the utter blindness of Lord Carnarvon in the discernment of sentiment in others which takes a different direction from his own. What Mr. Mill did with unequaled success was that which we have already indicated. He endeavored, when engaged in the investigation of truth, to avoid the bias of sentiment; but it needs no prophet to tell us that in this he was impelled by a loyalty to truth springing out of his conviction of its importance to the interests of his kind. Indeed, if thoroughly scientific men were as devoid of feeling as Lord Carnarvon represented them, his fear of them would be ludicrous. They are a mere handful of men. They have arrayed against them the prejudices of mankind, the interests of the ruling classes all over Europe, and a powerful and well-paid ecclesiastical organization. What reason is there to be in "great dread" that a few men without feeling or devotion will triumph over such great odds? The truth is, that what is making the wearers of coronets and mitres tremble is, not the absence of religious feeling from social philosophy, but the union of the two. Mr. Mill has done more than any one in modern times to effect that union. It shines through his works on even the most abstract of subjects as a halo, and deep in the hearts of the most powerful intellects of our country are to be found the sentiments which he did so much to rouse and to direct. Hence these tears.

SKETCH OF R. A. PROCTOR.

IN making use of the sciences for purposes of intellectual cultivation, a distinction has been drawn between those that are fixed, or established, and those that are progressive, and it has been maintained that the former alone are to be admitted for the purposes of mental training. Foremost among these are Mathematics, Astronomy, and Molar Physics, or the laws of the motion of masses. These may be introduced as means of scientific education, while Molecular Physics, Chemistry, and Biology, from their unsettled character, are alleged

to be unfit for such employment. There are no doubt reasons for this distinction, whether conclusive or not, but the classification is by no means above criticism, for within our own time Astronomy has been taken out of the category of the established or perfect sciences, and may be now cited as one of the best illustrations of a progressive science. Of course, there are established truths in Astronomy, and so there are in Chemistry and Physics, but Astronomy has now assumed a new character of progressiveness, and within the present generation it has surpassed all the other sciences in the rapidity and splendor of its advancement.

Not so many years ago it seemed as though astronomy were approaching, if it had not already reached, its final stage. The Sun and his family had been measured and weighed, the Moon tracked in all her motions, and the paths of comets determined. The younger Herschel had completed the survey of the heavens, which his father commenced, and, to all seeming, little remained to be ascertained about the universe. And yet, in the presence of the astronomy of our day, that of a few years ago looks crude and elementary. Newton made an epoch by bringing the movements of the planetary bodies under the demonstrated laws of terrestrial force; Kirchhoff and the spectroscopists have made a new era by subordinating stars, comets, and nebulæ, to the laws of terrestrial chemistry. The recent physical explorations of the sun constitute one of the most thrilling chapters in all science. Nor have astronomers been content with the unquestioned acceptance of the older views respecting the planetary scheme. Not Ptolemy alone, or Hipparchus, Galileo, Kepler, and Newton, but even the elder and younger Herschel, would stand aghast at the change of opinion that has been wrought regarding the members of the solar system. Jupiter and Saturn, so long considered as merely large specimens of habitable worlds, have taken their place in a higher order of orbs, while satellites, formerly thought to be set as lights to illumine their primaries, have been raised almost to the dignity of planets. Even more surprising have been the discoveries made respecting comets and meteors, while modern inquiries have not stopped short of the domain of the so-called fixed stars, so that the whole scheme of the stellar universe begins to present a new aspect.

Astronomical science, in short, has been enlarged and reshaped in the nature and scope of its problems, and has entered into a new epoch in our own time which opens to us even a grander future than was disclosed either to Copernicus or to Newton.

As was quite unavoidable, this recent revolution or extension of the science has left behind the old teachers, and created a demand for new men, who can deal with the subject in its more novel and extended aspects. And, as supply follows demand in the intellectual as well as the commercial world, the expounders of the new dispensation

are forthcoming as required. Eminent among these is the subject of the present sketch, who has come over from England to lecture upon astronomical subjects. Ten years ago he was unknown, but within that time he has won a prominent position both as an investigator of celestial phenomena, and as an eloquent and instructive writer upon the most modern phases of the science. Of his wonderful industry and remarkable versatility the following sketch will furnish abundant evidence, but we were hardly prepared to expect that Mr. Proctor would sustain his eminent reputation in the new field of popular lecturing, yet such is the fact. He is an easy and fluent extemporaneous speaker, enthusiastic over his themes, and wielding his large resources of knowledge with the utmost facility and readiness. Dealing with the sublimest of all subjects in its latest and most novel aspects, he carries his audience with him, and occupies their attention so completely that they lose the sense of time, and reach the close of a long lecture under the impression that it is but fairly begun.

Richard Anthony Proctor was born at Chelsea, March 23, 1837, and is consequently not yet thirty-seven years of age. He was educated in his boyhood chiefly at home, being delicate in health. He was a diligent reader, his tastes inclining to history, literature, and theology, more than to mathematics or the sciences. He showed a great liking for the construction of maps, and still regards charting not only as an important aid in scientific investigation, but as a very instructive mental exercise. At the age of twelve he began to read Euclid in school, and at once took to geometrical study. At thirteen his father died, and the boy soon after left school. He was now a ward in chancery; and it affords a good illustration of the system attacked by Dickens in "Bleak House" that, although there was not any "suit" properly so called, Mrs. Proctor was engaged for three or four years in an expensive series of legal processes, the sole object of which was to assign to her formally on behalf of her children the proceeds of a certain estate of which they were heirs.

In 1854 young Proctor obtained a clerkship in a bank to aid him in getting the means of going to the university, as he was designed for a clergyman in the English Church. But little time was allowed for study; but when, in 1855, he went to King's College, London, he succeeded in taking first place in seven subjects—classics, mathematics, history, literature, divinity, French, and German. In 1856 he entered St. John's College, Cambridge, where he distinguished himself in mathematics. In 1857 he lost his mother, for whose sake alone he had valued college successes; and he no longer pursued his mathematical studies, though he remained at Cambridge, and took the degree of B. A. in 1860.

Although he went into the Cambridge Senate House for examination, after two years of mathematical idleness, and without any acquaintance with the higher and more important branches of mathemati-

cal reading, Mr. Proctor is reported as standing high in the university among the "wranglers." We have wranglers in this country, and keep a whole Congress of them for public exhibition, as gladiators were exhibited at the Roman shows. But in the English universities this term is applied to a limited group of first-class students or honor-men who go in on the final scramble for the highest places in a numerical gradation. He who beats all the rest is called "senior wrangler." This is the highest position of university honor, and the struggle to reach it is so long and severe that it is said to "use up" the successful candidate, so that the "senior wrangler" is rarely heard of in afterlife. Then come second, third, and fourth wrangler, and so on, and even tenth wrangler is regarded as a highly-honorable rank, as in fact it is to be a wrangler at all. Fortunately for astronomy and American lecturing, Proctor did not win the headship in the wrangle of his year, but he is quoted as being close on the heels of the leaders.

Mr. Proctor's first literary effort, a nine-page article on "Double Stars," appeared in the *Cornhill Magazine* for December, 1863, ten years ago. His next attempt was an "Essay on the Rings of Saturn," which was declined, as not sufficiently popular for the readers of the *Cornhill Magazine*. This led to the writing of his first book, "Saturn and its System," a work chiefly remarkable for the fullness of the relations presented by a single planet, which are discussed in almost every conceivable aspect. The construction of maps to illustrate Saturn led Mr. Proctor to form his "Gnomonic Star Atlas," planned on an altogether original system. The sphere is supposed to be inclosed in a dodecahedron, on whose twelve pentagonal faces the stars are projected. A third work, called "The Handbook of the Stars," was also ready for the press in 1866. In this year an event occurred which rendered literary and scientific labor, hitherto pursued as an amusement, a necessity of existence. The bank in which he had all his fortune broke and left him worse than bankrupt, for he was liable for many thousand pounds, and from this liability he has but very recently obtained release. The three years following were marked with struggles, difficulties, and severe domestic bereavements, which interrupted literary work. In 1867 "Constellation-Seasons" (now out of print), and "Sun Views of the Earth," were produced, as well as charts of the planetary orbits, projections of Mars, and other maps. In 1868 appeared "Half-Hours with the Telescope," and in 1869 "Half-Hours with the Stars." But the chief occupation of Mr. Proctor's time for the three years consisted in essay-writing for the magazines, and in the preparation of works which publishers rejected at the time, but which have since met with a success altogether unusual in scientific literature.

In 1868 Mr. Proctor commenced writing popular science essays for the London *Daily News*, and has continued to do so until the present time. In 1870 appeared "Other Worlds than Ours," which had a

prompt and remarkable success, and in the same year his large "Star Atlas" was published. Early in 1871 "The Sun" was printed, and was also well received. In the same year appeared "Elementary Lessons in Astronomy," and the first series of "Light Science for Leisure Hours;" in 1872 the "School Atlas of Astronomy," "Essays on Astronomy," "Orbs around Us," and "Elementary Lessons in Physical Geography." Much of his time this year was devoted to the construction of a chart, showing all the stars visible in the northern heavens with the telescopes $2\frac{3}{4}$ inches in aperture—in all, 324,198 stars. This chart exhibits relations having an important bearing on our ideas respecting the constitution of the heavens. During the past year Mr. Proctor has published the second series of "Light Science," "The Moon," "The Border-land of Science," "The Expanse of Heaven;" and a new work, entitled "The Universe and the Coming Transits," is now passing through the press.

Such a rapid multiplication of books cannot of course be otherwise than unfavorable to the promotion of science by original research. This Mr. Proctor recognizes, and he has described it as one of the principal hardships occasioned by the loss of his property, that he was compelled to give but a limited portion of his time to original investigations. But, although driven to write about science for a livelihood, or to forsake it altogether for more remunerative employment, he is very far from having neglected the more serious work of research. Few know what can be accomplished by industry and perseverance. It is only necessary to look over the index of the Proceedings of the Royal Astronomical Society to see that Mr. Proctor has been a large contributor to its work. Indeed, although its pages are limited to the record of such work, from 1868 to 1873 Mr. Proctor contributed to these proceedings more freely than any fellow of the Astronomical Society. His papers have related chiefly to the stellar system, the laws of distribution of stars, their motions, the relations between stars and nebulæ, and the general constitution of the heavens. But the subject of the solar corona has occupied a considerable space among Mr. Proctor's papers, while even a larger amount of labor has been given to the investigation of the opportunities which will be presented during the transits of Venus, on December 9, 1874, and December 6, 1882.

The subject of that mysterious connection between meteors and comets which forms one of the most surprising of the results of modern observation has also been largely dealt with by Mr. Proctor. His investigation of the rotation-period of the planet Mars, resulting in a value certainly within one-tenth of a second of the true period, may also be mentioned among his original researches.

It is but just to say that Mr. Proctor has been singularly fortunate in enunciating theories which have been subsequently confirmed, und in some cases demonstrated by new observations. His confident tone

respecting the solar theory of the corona in 1870 and 1871 was blamed by some and misunderstood by many, who failed to perceive his reason for urging arguments so strongly on a matter seemingly theoretical. That reason was stated by Mr. Proctor in the preface to the first edition of the "Other Worlds," where he expresses his anxiety lest doubt and confusion, prevailing as to a matter really demonstrated, might cause the opportunities presented by the great solar eclipses of 1870 and 1871 to be frittered away. Mr. Proctor's confidence on the one hand and his anxiety on the other were fully justified by the event. Every astronomer now accepts the solar theory of the corona, and few are ignorant how, at the eclipse of 1871, two-thirds of the observers were set by the chief believer in the terrestrial theory to make observations which proved nothing, and which, but for faith in that exploded theory, would never have been thought of.

The controversy respecting the transits of Venus, begun in 1869, and brought to a close quite recently, led to unpleasant relations between Mr. Proctor and the Astronomer Royal. Indeed, it must be admitted that in conducting this controversy after February, 1873, Mr. Proctor exhibited a zeal which at times seemed uncalled for. But some explanation may be found in the fact that, having remained quiescent, at the Astronomer Royal's special request, for a long time, his renewal of the discussion led immediately to the statement that it was now too late for any change of plan. Fortunately, the results of the inquiries of American, Russian, and German astronomers, as well as the nature of the schemes proposed by them, fortified Mr. Proctor's position; and, even while the Astronomer Royal was proclaiming his conviction that no other nation would adopt the same opinions as Mr. Proctor, news reached England that America, Russia, and Germany, were in accord in these matters. It cannot be wondered at that, at the Greenwich Board of Visitation, Prof. Adams proposed, and the Board unanimously voted, the point which Mr. Proctor had urged in 1869, viz., that it was desirable to apply Halley's method (respecting which Airy had said, in December, 1868, that it "failed totally"). In this matter, as in the controversy respecting the sun's corona—the only controversies in which Mr. Proctor has engaged—there was this obvious reason for pressing the discussion, that eclipses and transits will wait for no man. In his main subject of original investigation—the constitution of the heavens—Mr. Proctor has wisely avoided controversy, contenting himself with advancing and advocating his views, collecting evidence, weighing objections, and endeavoring to progress toward the solution of the difficult but interesting problems associated with the subject.

CORRESPONDENCE.

MR. GLADSTONE CORRECTS MR. SPENCER.

IN reply to Herbert Spencer's last paper on the "Study of Sociology" (in POPULAR SCIENCE MONTHLY for December, 1873, p. 134), Mr. Gladstone sent the following letter to the editor of the *Contemporary Review:*

10 DOWNING STREET, WHITEHALL, *November* 3, 1873.

MY DEAR SIR: I observe in the *Contemporary Review* for October, p. 670, that the following words are quoted from an address of mine at Liverpool:

"Upon the ground of what is termed evolution, God is relieved of the labor of creation: in the name of unchangeable laws, He is discharged from governing the world."

The distinguished writer in the *Review* says that by these words I have made myself so conspicuously the champion (or exponent) of the anti-scientific view, that the words may be regarded as typical.

To go as directly as may be to my point, I consider this judgment upon my declaration to be founded on an assumption or belief that it contains a condemnation of evolution, and of the doctrine of unchangeable laws. I submit that it contains no such thing. Let me illustrate by saying, What if I wrote as follows:

"Upon the ground of what is termed liberty, flagrant crimes have been committed: and (likewise) in the name of law and order, human rights have been trodden under foot."

I should not by thus writing condemn liberty, or condemn law and order; but condemn only the inferences that men draw, or say they draw, from them. Up to that point the parallel is exact: and I hope it will be seen that Mr. Spencer has inadvertently put upon my words a meaning they do not bear.

Using the parallel thus far for the sake of clearness, I carry it no farther. For while I am ready to give in my adhesion to liberty, and likewise to law and order, on evolution and on unchangeable laws I had rather be excused.

The words with which I think Madame de Staël ends "Corinne," are the best for me: "*Je ne veux ni la blâmer, ni l'absoudre.*" Before I could presume to give an opinion on evolution, or on unchangeable laws, I should wish to know, more clearly and more fully than I yet know, the meaning attached to those phrases by the chief apostles of the doctrines: and very likely, even after accomplishing this preliminary stage, I might find myself insufficiently supplied with the knowledge required to draw the line between true and false.

I have, then, no repugnance to any conclusions whatever, legitimately arising upon well-ascertained facts or well-tested reasonings: and my complaint is that the functions of the Almighty as Creator and Governor of the world are denied upon grounds, which, whatever be the extension given to the phrases I have quoted, appear to me to be utterly and manifestly insufficient to warrant such denial.

I am desirous to liberate myself from a supposition alien, I think, to my whole habit of mind and life. But I do not desire to effect this by the method of controversy; and if Mr. Spencer does not see, or does not think, that he has mistaken the meaning of my words, I have no more darts to throw; and will do myself, indeed, the pleasure of concluding with a frank avowal that his manner of handling what he must naturally consider to be a gross piece of folly is as far as possible from being offensive.

Believe me, most faithfully yours,

W. E. GLADSTONE.

MR. SPENCER ON THE CORRECTION.

To the second edition of Mr. Spencer's "Study of Sociology," he appends the foregoing letter, and remarks as follows (page 425):

Mr. Gladstone's explanation of his own meaning must, of course, be accepted; and,

inserting a special reference to it in the stereotype-plate, I here append his letter, that the reader may not be misled by my comments. Paying due respect to Mr. Gladstone's wish to avoid controversy, I will say no more here than seems needful to excuse myself for having misconstrued his words. "Evolution," as I understand it, and "creation," as usually understood, are mutually exclusive: if there has been that special formation and adjustment commonly meant by creation, there has not been evolution; if there has been evolution, there has not been special creation. Similarly, unchangeable laws, as conceived by a man of science, negative the current conception of divine government, which implies interferences or special providences: if the laws are unchangeable, they are never traversed by divine volitions suspending them: if God alters the predetermined course of things from time to time, the laws are not unchangeable. I assumed that Mr. Gladstone used the terms in these mutually-exclusive senses; but my assumption appears to have been a wrong one. This is manifest to me on reading what he instances as parallel antitheses; seeing that the terms of his parallel antitheses are not mutually exclusive. That which excludes "liberty," and is excluded by it, is despotism; and that which excludes "law and order," and is excluded by them, is anarchy. Were these mutually-exclusive conceptions used, Mr. Gladstone's parallel would be transformed thus:

"Upon the ground of what is termed liberty, there has been rebellion against despotism: and (likewise) in the name of law and order, anarchy has been striven against."

As this is the parallel Mr. Gladstone would have drawn had the words of his statement been used in the senses I supposed, it is clear that I misconceived the meanings he gave to them; and I must, therefore, ask the reader to be on his guard against a kindred misconception.

I have not, however, thought it needful to change the description given of Mr. Gladstone's position, or to suppress the comments made upon it; because the substantial truth of this description is shown by the other passage quoted, the manifest meaning of which he does not disclaim. By characterizing Science as having "gone to war with Providence"—by displaying an unhesitating belief that great men are providentially raised up at the needful times, and by speaking with alarm and reprobation of the belief that their rise is due solely to natural causes, Mr. Gladstone does, I think, give me adequate warrant for taking his view as typical of the anti-scientific view in general—at any rate, in so far as the Social Science is concerned. Though this view may not be incongruous with the conception he entertains of Science, yet it is certainly incongruous with the conception entertained by scientific men; who daily add to the evidence, already overwhelming, that the Power manifested to us throughout the Universe, from the movements of stars to the unfolding of individual men and the formation of public opinions, is a Power which, amid infinite multiformities and complexities, works in ways that are absolutely uniform.

NOTE ON THE PHYSICAL CONSTITUTION OF MATTER.

To the Editor of the Popular Science Monthly:

I HAVE read, with much interest, the elaborate articles, by Judge Stallo, on "The Primary Concepts of Modern Physical Science," hoping, from the scholarly manner in which the author discusses the subject, that he would conduct us to some more acceptable conclusion than has hitherto been arrived at. I was disappointed, however, to find him surmounting the difficulties of the subject by assuming that the "typical and primary state of matter is a gas," which "is not a group of absolute solids, but is elastic to the core."

I do not propose to review nor criticise these learned articles of Judge Stallo, though there are various portions that I think quite vulnerable to criticism; but I must confess that the idea of an unparticled elastic body is to me an utter impossibility.

The subject presents very grave difficulties under any view of the case. For, if we assume the existence of an ultimate solid particle, universal *force* cannot be conserved, because the interference of solid particles must *destroy* motion, and therefore force. Hence, in that view of the case, we must have a continual destruction,

and therefore a continual creation of force. This conclusion I am not willing to accept, as I fully believe in the indestructibility of both matter and force.

The least objectionable view that I have been able to arrive at is, that all *ideas* are sensations excited primarily by material impressions, and hence that we can have absolutely no idea of space independent of matter.

And, as a stellar system in the universe of matter consists of millions of aggregated masses which are individually very small in proportion to the inter-spaces, so I believe that the chemical molecule is very small in proportion to the space between the molecules. And as each *sun* has (probably) various attendants (the planets), so each chemical molecule consists in general of several different bodies that may be easily separated (in consequence of the space between them being of the same *order* as the spaces between the molecules). But, like the different bodies of the solar system, or of a stellar system, each of these bodies is a compound mass consisting of millions of units of a different *order*, holding probably the same relation to the chemical molecule that the chemical molecule does to the matter of the solar system; and so on, both upward and downward, to infinity.

There is, therefore, as I conceive, absolutely no limit to the division of matter, physically as well as mathematically; but our organization is such that, of the infinite series of terms in which it manifests itself, we can know, experimentally, only two: viz., the stellar universe, constituting the first *order*, of which the stars and the planets are the units; and, secondly, the chemical molecule, which constitutes the second *order*.

According to this view, the material universe might be represented, in *orders*, by the following series: $d^{-n}x, \ldots d^{-3}x, d^{-2}x, d^{-1}x, d^{0}x, dx, d^{2}x, d^{3}x, \ldots d^{n-1}x, d^{n}x$, in which x is the unknown quantity, which we call matter, and n and n are both infinitely great.

In this series, $d^{0}x$, or simply x, would represent all tangible matter; and dx, which is the next term *descending*, would represent chemical molecules and their constituents, the atoms of all known and unknown elementary bodies.

As in the analogous expression used in mathematical investigations, $d^{2}x$ is infinitely small in respect to dx, which in its turn is infinitely small in respect to $d^{0}x$, and so on; yet each represents the elements of which the next preceding *order* is constituted. So in the physical world, as represented by the above series: the units in x, which are represented by the visible worlds in space, are infinitely large when compared with the units in dx, which are represented by the chemical molecules; the units in each preceding order, *in both series*, being aggregations of the units in the next succeeding *order*.

This view of the constitution of matter, though it necessitates the assumption of its actual infinite *division*, yet, to my mind, involves much less absurdity than to suppose it imparticled, and yet "elastic to the core," or to suppose that the chemical molecule, or even the chemical atom, is an absolute solid.

J. E. HENDRICKS.

DES MOINES, IOWA, *November* 21, 1873.

MATTER, FORCE, AND INERTIA.

To the Editor of the Popular Science Monthly:

JUDGE STALLO'S valuable contributions to the POPULAR SCIENCE MONTHLY, on the "Primary Concepts of Modern Science," can scarcely fail to give the reader a clearer conception of elementary being. But it seems to me that his criticism of Mr. Faraday's "complex forces," and Baine's assertion that "matter, force, and inertia, are substantially three names for the same fact," is clearly illogical.

On the ground that the existence of all reality lies in relation and contrast, the author assumes that inertia and force are ever coexisting contrasts. He says: "We know nothing of force except by its contrast with mass, or (what is the same thing) inertia; and, conversely, as I have already pointed out in my first article, we know nothing of mass, except by its relation to force. Mass, inertia (or, as it is sometimes though inaccurately called, matter *per se*) is indistinguishable from absolute nothingness; for matter reveals its presence, or evinces its reality, only in its action, its

force, its tension or motion. . . . It is impossible, therefore, to construct matter by a mere synthesis of forces."

Now, as all conceptions result from motion in the brain, it is self-evident that motion is the primordial reality whence all concepts arise, and that different conceptions of realities are solely different modes of motion, each distinct attribute being a distinct mode, and modified attributes are modified modes. Therefore a conception of matter, mass, inertia, or momentum, being solely a product of motion in the brain, and a conception of color being solely a product of motion in the brain, it is again self-evident that the only possible difference, between the primordial realities we call inertia and color, is difference in modes of motion.

Hence it is seen that the idea—almost universal—that inertia, or momentum, necessarily coexists with motion, may have no foundation in fact; its error being further evidenced by our non-perception of their coexistence in the invisible, or molecular motions. In fact, inertia or momentum is only perceived in that single mode of motion which produces the sensation of touch; and which we designate as mechanical or mass-motion.

But whether or not momentum necessarily accompanies motion, it was shown above that the same reason for conceiving color to be solely a mode of motion equally obtains in our conception of matter, mass, or inertia, as a mode of motion; and that "all the reality we know" exists, primarily, in changing, but ever-existing, relations and contrasts of modes of motion.

A. Arnold.

EDITOR'S TABLE.

AGASSIZ.

OUR great naturalist has finished his work and passed away. His loss will be felt throughout the scientific world, and will be deeply lamented beyond the circles of science in all parts of our own country. Although he had accomplished much during a long and active life, he entertained no thought of rest, but was still full of hope, ambition, and large plans of labor, such as belong to the prime of manhood. But his physical powers at last gave way, and his career terminated, we might almost say prematurely, at the age of sixty-six. Of Prof. Agassiz's more strictly scientific labors we shall take an early opportunity to speak; we can here only briefly refer to some of the leading features of his career and character.

Prof. Agassiz was by descent a Frenchman, his family being among the Huguenots who were driven from France by the revocation of the Edict of Nantes, in the year 1685, and took refuge in Switzerland. He came of a theological stock, being derived from six lineal generations of clergymen. He was born in 1807, the year that the first steamboat started on the Hudson, and when Humboldt, Cuvier, and Napoleon, were thirty-eight years of age.

It has been Prof. Agassiz's fortune to take a very conspicuous part in the scientific work of the present time. The Old World gave him his education, and the New World the best opportunity of using it. He was early and powerfully attracted to the study of Nature, while his mind was moulded and matured through intimate intercourse with the most illustrious men of science in Europe. He did his chief original work, and developed the views with which his name will be mainly associated, in his youth and middle life, and at the age of thirty-nine he left the continent, where scientific men abounded, and took up his residence in a new country where they were wanted, and where the opportunities, both of entering unexplored fields of investigation and of drawing men and institutions

into the work, were alike unparalleled; while the course he pursued has turned out as wise for his own fame as it has proved favorable to the interests of advancing knowledge.

It is well known that Prof. Agassiz was a man of strong personality. He had great enthusiasm and impulsiveness, and the whole fervor and intensity of his nature was spent in the single-minded pursuit of science. Not content with what he could himself know, and do, and enjoy, he was powerfully impelled to make others the sharers of his knowledge, his activity, and his pleasures. He not only won them to him by his geniality, and his cordial and unaffected manners, but he inspired them with his own purposes, and moved them to his own ends. Sympathetic with all who were interested in science, he especially fascinated young men, and the ranks of our naturalists are full of those who were recruited to the work by his agency, among whom may be mentioned Verrill, Stimson, Clark, Hyatt, Putnam, Packard, Scudder, Hartt, Tenney, Morse, Niles, and Bickmore. One of his students writes of him as follows:

"Agassiz's enthusiasm did not consist merely in scientific investigation and in earnest words, but also in earnest deeds in relation to others, and especially in relation to young men. Wherever he saw a student who would study Nature, he opened the way for him, took him into his laboratory, spread his treasures before him and directed his studies, and this too without any expectation or thought of a pecuniary reward as a return. Indeed, I do not know of a single student who ever paid him a dollar as tuition for his instruction in natural history studies. Young men came and staid and studied as long as they would, and, as far as tuition was concerned, without money and without price. To the present writer he said, twenty years ago: 'Whenever you get ready to study natural history, come to Cambridge, and remember it will not cost you a cent of money.'"

But Prof. Agassiz's influence was far from being confined to a small class of congenial students; it was very powerful upon the general public. A republican by nativity, and a republican by adoption, he was also a republican in sympathy and in principle, by association and habit. Although coming to this country as a great man from Europe, he had no factitious dignity to sustain, and no scruples to overcome, in plunging at once into the work of popular teaching. Entering early and fully into the spirit of our institutions, he went among the people at large, gave courses of lectures upon zoology in all the chief towns of the country, and was indefatigable in the diffusion of knowledge, and in awakening a higher appreciation of science among the people. In this he was wise and sagacious to the specific ends he had in view, for he well understood that in this country the prosperity of science is ultimately bound up with its public appreciation. In this field of effort too he was preëminently successful. As Mr. Beecher remarks, in the *Christian Union:*

"Agassiz stepped upon the lecture platform in Boston, and day after day fascinated a great audience with the fairy tales of science and the long result of time. That appreciation might have been predicted of Boston culture, perhaps. But when the master took his black-board and his problems to the smaller cities, drawing his queer diagrams, and unfolding their vast meaning before lyceum associations, normal schools, colleges, high-schools, those benches, too, were crowded with eager and intelligent listeners. It was Agassiz who made straight the path of Tyndall last winter, created the demand for Huxley's lectures, and made THE POPULAR SCIENCE MONTHLY as much a necessity as *Harper* or the *Atlantic*. It was Agassiz whose large intent laid the corner-stone of our institutes of technology, and scientific schools in colleges."

But no estimate of Prof. Agassiz's real work among the American people will be just that stops here. True, he gave his best powers to the instruction of teachers, farmers, mechanics, and artisans, but it was not merely as a

scatterer of his own stores of knowledge. He had a profound interest in popular education, but the soul of that interest was for improvement in its methods. In the matter of public instruction he was a revolutionist and a propagandist. He warred with current ideas and consecrated practices. He condemned in the most emphatic way the wretched lesson-learning routine that prevails in the schools. He denounced our wordy and bookish education as baseless and unreal, and demanded such a change in our systems of instruction as shall bring the pupils face to face with Nature herself, and call out the mind by direct exercise upon phenomena—the facts, laws, relations, and realities of the world of experience. He was at times inclined to take discouraging views of the educational future, from this enslavement of the schools to vicious methods of study, but he never wearied in the endeavor to propagate more rational opinions, and we cannot doubt that the seed thus sown will yet ripen into most valuable fruit. It is questionable, indeed, if his earnest exertions in this direction will not tell in the final promotion of science even more powerfully than all his attempts to attain immediate results.

Another feature of Prof. Agassiz's scientific character remains to be noticed. Science was to him not merely the knowledge of animals, rocks, and glaciers, but it was a method of thought, rising into the proportions of a philosophy, and embracing the interests of humanity. By the vulgar-minded he was looked upon as a very wonderful man, whose genius spent itself upon crabs and their kindred, and who would give the world for a new fish. This was regarded as an amiable and an admirable eccentricity, and everybody was pleased when he had got a new donation to buy more curious things for his museum. And it was freely said, "If men of science would only imitate Agassiz, and be content with their dissections and collections, and keep in their sphere, and not encroach upon departments of thought which belong to politicians, theologians, historians, and philanthropists, the world might get on in peace." But this is a very mistaken conception of Agassiz's views of science. He saw in it not only a disclosure of the laws of physical nature, and an interpretation of the principles of life, but a revelation of correlated truths of all orders indispensable to the progress of man. This he ever maintained, and this he affirmed in the last essay perhaps that he ever wrote, and which was published in the *Atlantic Monthly* but a few days after his death. In that article there occurs the following passage, which our readers will attest might have been a fit motto for THE POPULAR SCIENCE MONTHLY:

"It cannot be too soon understood that science is one, and that whether we investigate philosophy, theology, history, or physics, we are dealing with the same problem, culminating in the knowledge of ourselves. Speech is known only in connection with the organs of man, thought in connection with his brain, religion as the expression of his aspirations, history as the record of his deeds, and physical sciences as the laws under which he lives. Philosophers and theologians have yet to learn that a physical fact is as sacred as a moral principle. Our own nature demands from us this double allegiance."

WE had intended to say nothing at the present time about Agassiz and Evolution, thinking it most suitable to forget all differences in the heart-felt acknowledgment of what we owe to his noble and disinterested life. But the occasion of his death has been so widely used in the interest of prejudice and error that a few words upon this subject become unavoidable.

Prof. Agassiz was an opponent of Darwinism, but his opposition gave no excuse for the amount of stupid rant upon the question which has been late-

ly poured forth. The following passage from an elaborate article on Prof. Agassiz, in one of our leading morning papers, is a fair example of a good deal of the talk that has been latterly indulged in by the press: "His views of the development of animal species, opposed entirely to the gloomy theory of Darwin, which has fallen so oppressively upon the world, while they neglect no fact and break no link in the chain of progress, are marked by a recognition of a distinct humanity and a high creative purpose in the Divine origin of all things which elevate and cheer and relieve us of the sickening consciousness that man, 'the paragon of animals,' is merely a growth from some shapeless, loathsome jelly."

We have here a moral estimate of "jelly," and a vehement denial of its fitness to be the material from which the "paragon of animals" originates; the bare idea being declared sufficient to shroud the universe in gloom, and fairly to make one sick. But perplexing questions here arise. *Omnes vivum ex ovo*, and the substance of all eggs is jelly; but, if this substance was not fit to use at the primal start of life, why is it so extensively employed now? If not fit for the elaboration of the lowest creatures, how came it to be employed in unfolding the "paragon?" and, if not always used, pray when and why was it introduced? One would think, from the writer's horror of "jelly," that he regarded it as a diabolical invention of Darwin; threatening a kind of gelatinous "fall of man," from which Prof. Agassiz has had the happiness of rescuing the world, and restoring it to cheerfulness. But really Mr. Darwin is responsible for neither the existence nor the office nor the extent of "jelly" in Nature; and of all men Prof. Agassiz is the last to lead a crusade against it. As an eminent embryologist, he might properly be called the high-priest of "jelly." He was never weary of explaining that all living things—each man, as well as every inferior animal—is actually evolved from a little mass of "jelly;" and, while he would probably have agreed as to its shapelessness, he would certainly have protested against its "loathsomeness." He who said that "our philosophers and theologians" (and, he might have added, our editors) require to be taught that "a physical fact is as sacred as a moral principle," would hardly have sickened over the "loathsomeness" of that plastic material which we know to be the starting-point of all organic development.

Agassiz held that Nature is to be regarded as the material embodiment of divine ideas, and, after dwelling with delight upon the curious forms and constitutions of creatures composed almost wholly of "jelly," he would say, "These are the thoughts of the Almighty." On his view, "jelly" was the chosen and specially honored material for the expression of the divine conceptions. Prof. Agassiz would certainly have considered the little protoplasmic speck, which, in the course of natural operations, can evolve in a few years into a Newton, a Shakespeare, or even a President of the United States, as an exceedingly interesting portion of the divine order. If the germ contains potentially the future being, and if a highly-developed race transmits its aptitudes and capacities from generation to generation, then is "jelly" an institution of God for the conservation of perfected man, and the civilization that he carries with him.

With such evidences as this of the prevailing state of mind, no wonder that the great naturalist was vehement almost to fanaticism in his advocacy of scientific education. In old prescientific times, Nature was held accursed; and that such stuff as we have here quoted could find entrance into a widely-circulated organ of public opinion, is proof to how great an extent we are still dominated by middle-age ideas.

Since his death, Prof. Agassiz has been much and ardently lauded as a Christian scientist, and a champion of the faith against scientific skepticism. It is gratifying to be assured that he was neither a Mohammedan, nor a Buddhist, nor a Sun-worshiper, but a good Christian, as he ought to have been; and here, perhaps, it would be as well to let the matter rest. But, when we are told that Agassiz was a Christian *because of his opposition to Darwinism*, we decidedly object. Prof. Agassiz was a Theist, who ascribed the universe to a Divine Mind; Darwinians do the same. That Prof. Agassiz has attempted to show the incompatibility of the Christian system of doctrine with Darwinian ideas, we are not aware; but, on the other hand, there are many Christian theologians who take the opposite view. As we show in another place, a literature of reconciliation is springing up, and we are beginning to hear of Christian evolutionists, as we have long heard of Christian astronomers and Christian geologists. But because Agassiz was a Theist, it by no means follows that his theories of Natural History were specially religious, and the attempt to make them so, so far as influential at all, will be doubly mischievous. It will prejudice scientific inquiry by favoring the idea that the results of investigation may be irreligious; and it will injure Christianity by identifying it with physical doctrines and interpretations of Nature, which it is the business of science to investigate, and which investigation is liable to change. He who insists upon linking religion to any view of natural phenomena, puts it in grave peril. The attempt, long ago made, to identify it with the belief in the flatness and fixity of the earth was a serious error; and the subsequent attempt to identify it with the doctrine of the recent creation of the earth was another mischievous mistake. To try the experiment a third time, in the domain of Biology, cannot fail to be still more injurious. It is believed by great numbers of the most intelligent students of the subject that the old opinions regarding the origin of living things upon earth are certainly doomed to pass away. At all events, the subject is unsettled, and it is therefore unwise to make Christianity a partisan to any of its theories.

It is well also to bear in mind that, if Agassiz fights Darwinism, he accepts Evolution. Forty years ago he wrote of the life upon the globe, "An invisible thread in all ages runs through its immense diversity, exhibiting as a general result the fact that there is a constant progress and development ending in man;" and, in his very last article, to the question, "Is there any such process as evolution in Nature?" he answers, "Unquestionably, yes." He was of opinion that little as yet has been contributed toward the scientific solution of this great problem; but, however that may be, evolution in Nature he conceded as a fact which belongs to the future of science. If, therefore, Agassiz was a Christian, belief in evolution is not inconsistent with Christianity. This is the ground now taken by many eminent theologians, who, like Dr. McCosh, maintain that Christianity has no interest in holding by the question one way or the other. Dr. Peabody, in his sermon at the funeral of Agassiz, took a similar position, and is reported to have said: "His repugnance to Darwinism grew in great part from his apprehension of its atheistical tendency, an apprehension which, I confess, I cannot share; for I forget not that these theories, now on the ascendant, are maintained by not a few devout Christian men, and while they seem to me unproved and incapable of demonstration, I could admit them without parting with one iota of my faith in God and Christ."

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES.

THE NEW CHEMISTRY. By J. P. COOKE, Professor of Chemistry in Harvard University. 326 pages. D. Appleton & Co. Price, $2.00.

IT is well known that chemical science has been recently undergoing a great change in its theory of the constitution of bodies. The Lavoisierean chemistry, or the dual chemistry, by which all compounds were supposed to be simply paired, as metal with metalloid, acid with base, may be fairly said to have passed away. New ideas have been introduced which were but partially and reluctantly received at first, and were indeed sharply resisted by the masters of the old method, but which have at length forced their way and grown into a definite system. With the breaking up of the old method the old nomenclature has been shattered, and a new nomenclature has taken its place. In chemistry, therefore, the present is a time of transition and discomfort. What was long settled, and upon which we reposed in the confidence that it would never be disturbed, has proved an insecure result of imperfect knowledge, but which has served the important office of bringing us up to higher and more perfect views. There is a sadness in parting with old familiar ideas, as with old friends, but changes must come. In chemistry, the facts had outgrown the theories that expressed them. New facts were discovered for which the old system could find no place, and these accumulated until at length a new method of interpretation was attained, by which chemical philosophy has been placed upon a broader and it is hoped a more enduring basis. But, whatever may be its permanence, it is now fairly established, and so marked is its contrast with past theories, and so distinct are its features, that it has become fully recognized as "The New Chemistry."

The new chemistry has been fully adopted by various authors in their text-books, and partially adopted by others; but only with subdued satisfaction, as in the first cases students have been frightened by the formidable array of strange terms, definitions, and ideas, and in the latter case they have been confused by the intermixture of different systems. The great need, therefore, was for a new and compendious work that should be simply devoted to an explanation of the new system. Prof. Cooke, of Cambridge, has undertaken this task in the book before us, and most successfully and admirably has he accomplished it. He had already published a large collegiate text-book of "Chemical Philosophy," on the new method, which he has taught for years to the classes of Harvard University. But the demand was so urgent for a separate volume, that should present in a clear and popular manner the new aspects in which chemical facts and principles are now regarded, that he was induced to undertake it, in the interest of general education. He prepared his views first as a course of lectures, which were delivered at the Lowell Institute, in Boston. It was there shown that "The New Chemistry" may be made attractive to a general audience, as these lectures excited much interest, and were listened to with earnest attention throughout. After being thus tested, they were thoroughly revised by their author, and are now published, with illustrations, in a neat and convenient form. No book in the whole range of science was so greatly needed as this, and it is fortunate for the public that the want was supplied by such an able hand. Not only the chemical student, but all who are interested in this fascinating science, and all who are concerned with the advancement of scientific ideas, will find that this volume bridges over the gap between the old and the new, and will prove a most valuable introduction to the larger treatises which represent the present state of the science.

This is the first American volume contributed to the International Scientific Series, and, as it is unquestionably the best book in any language upon the subject, it will be sure to increase the already high reputation of these publications.

THE INTERNATIONAL REVIEW. Six Times a Year. January, 1874. 144 pages. Price, $5.00 a Year. A. S. Barnes & Co.

THE first number of this periodical contains six articles, as follows: I. Our Late Panic. II. Fires in American Cities, by

Prof. A. P. PEABODY, D. D., Cambridge, Mass. III. Deep-Sea Exploration, by Prof. WM. B. CARPENTER, M. D., LL. D., F. R. S., London. IV. Universal Education, by RAY PALMER, D. D., New York. V. The Prussian Church Law, by Baron FRANZ VON HOLTZENDORFF, LL. D., Munich. VI. International Arbitration, by THEODORE D. WOOLSEY, D. D., LL. D., New Haven.

It is always unfair to judge a periodical enterprise like this by its first number; for, although, in the present case, there has been long preparation, nothing can compensate for want of experience and the advantages of public criticism. The present number contains much good reading, although it is rather the opposite of lively. Half its articles are by D. D.'s, which gives promise that it is to be safely and conservatively conducted. This is important, as we must have ratchet-gear to hold what the driving impulses of advancing thought have gained. Yet it is very easy to pass from conservation to obstruction; and the somewhat spiteful kick given to Prof. Bain for his little book on "Mind and Body," while it seems to indicate the whereabouts of the *International*, suggests also that its editor may be in danger of overlooking the above distinction. The position taken being important as a symptom of the future course of the *Review*, it is worthy of some remark.

The school of mental philosophy, of which Bain is a leading representative, differs from the old metaphysical school in considering mind and body together, in their connections, interactions, and dependencies; and in maintaining that there can be no true mental *philosophy* without taking both factors into account. The old metaphysicians attended to the one and neglected the other; and what was worse, they magnified the one and decried the other, drawing perpetual contrasts between spiritual mind and "mere brute matter." An undoubted and very important step forward has been made in the scientific study of both orders of phenomena, as we find them related in Nature and in fact. Modern psychology, indeed, differs from the old metaphysics simply in conquering its prejudices, in taking into account all the elements of the problem, and treating them by the scientific method. Very naturally, the special work to be done has been to bring forward and assign its proper place to the neglected element, matter; whereupon the partisans of the old view make an endless ado about the encroachments of Materialism. When Prof. Bain refers to the structure of the brain, in the albuminous tissues and corpuscles of which all our natural and acquired aptitudes are stored up, the writer in the *International* is offended at such a "gross form of expression," and sighs for the good old times of Reid and Stewart, who "seem like intellectual giants when compared with the Professor of Aberdeen."

The writer observes that "nothing is more certain than our ability to separate mental and physical phenomena," and he might have added that bullets, strychnine, and lightning, are the most effectual means of doing it. But, when the separation is effected, mental phenomena disappear, and there is, therefore, an end to the study of mind. Of mental phenomena dissociated from physical phenomena we know absolutely nothing. If the writer means that "nothing is more certain than our ability to separate mental and physical phenomena" for the purpose of inquiring into their nature and laws, then we say that nothing is more false than the statement. We know nothing of mind, except as limited and conditioned by association with matter. The mode of union is a mystery, but the fact of union and of unity is undeniable. The very essence of the mystery is the oneness of that which exhibits such widely-different effects. The animate organism manifests at the same time psychical and material properties. We may confine our attention to either, or to parts of either, but we cannot separate them. Theory after theory has been offered for thousands of years to explain the relation. Science takes things as it finds them, and occupies itself in tracing the relations and dependencies among the phenomenal effects. This is Prof. Bain's method, and he has made it his great task to bring forward the long-neglected corporeal side of the inquiry, and to include the body in the study of the mind. Metaphysics does not require this, but science does require it, and the later

psychology recognizes it. It is futile to talk of going back to Reid and Stewart, or to look for the coming genius who is to restore them; their period is gone by.

RELIGION AND SCIENCE. A Series of Sunday Lectures, on the Relation of Natural and Revealed Religion; or, the Truths revealed in Nature and Scripture. By JOSEPH LE CONTE, Professor of Geology and Natural History in the University of California. 324 pages. D. Appleton & Co.

THE rapid multiplication of works at the present time which aim to bring the views of modern science into harmony with religious doctrines, is at once an attestation of the increasing interest generally taken in scientific subjects, and of the growth of a catholic and more tolerant spirit in regard to scientific and theological diversities of opinion resulting in more earnest efforts to harmonize them. The necessity for such reconciliations has arisen from time to time from the fact that theology has lent its sanction to given interpretations of natural things, while it has been the general work of science to revise and often to set aside such interpretations in the course of its progress. The main difficulty in this work of reconciliation has been the want of minds great enough to grasp and to master both spheres of inquiry. The efforts at harmonization have generally come from partisans of opposing views, who aimed at agreement by demanding great concessions from the opposite side. The scientists often ask theologians to renounce the main pretensions of theology for the sake of peace, and the theologians request the scientists to eschew three-fourths of what they believe as mere pseudo-science, that concord of opinion may be reached. And so they have alternated between treating and fighting, until at last a peace is conquered. Mean time, as the battle subsides in one field, it breaks out in another. In the field of Astronomy, where once the conflict raged with the greatest fury, all is now serene, and the Geological struggle has also become a memory. In the field of Evolution, there is still a kind of warfare, much din and smoke, and some bruises, if little slaughter. But the conflict is now undoubtedly more mild and restrained, as it will probably be more brief. In reviewing the past epochs of the conflict, it would be unwise to forget that both parties to the strife have often cared more for the combat than the cause, and, as in street-brawls, have often turned upon the peace-maker, for human nature is pugnacious, and dislikes to be interrupted in a good fight. But it is one of the grand offices of science to substitute truth for victory in the mental conflicts of men, and therefore to reduce the virulence of polemics. This is one of the ways in which science exerts a liberalizing influence, and, as the acerbities of controversy abate, and the passions are less enlisted, the harsher points of disagreement may be expected gradually to drop away.

Prof. Le Conte's admirable little book is born of the best spirit of conciliation, and goes over the whole ground of conflict, in its latest aspects, between Religion and Science. In his preface he says: "The series of lectures contained in this little volume is the result of an earnest attempt to reconcile the truths revealed in Scripture with those revealed in Nature, by one who has, all his active life, been a reverent student of both;" and he adds: "I may not entirely please either the mere scientist on the one hand, or the mere theologian on the other, but I have no apology to make for this. Perhaps my views may be all the more rational on that very account."

Prof. Le Conte's book has the rare advantage of having been produced by a man not only of profoundly earnest convictions, but of thorough intellectual preparation. His high position in the world of science has been long assured through his original contributions to some of its highest questions. He was one of the pioneer expositors of the doctrine of the correlation of forces in its application to life and its organization, and shows a wide and clear understanding of the various bearings of recent scientific inquiry. On the other hand, he holds to the great fundamental tenets of orthodox Christianity, and is therefore thoroughly prepared to consider the mutual relations of these systems of thought. Holding that all truth is one, and ever consistent with itself, he points out the past grounds of misapprehension, and shows how they may be removed, and reconciliation attained.

Of the success of his attempt there will be various estimates, but there can be but one opinion upon the point that he has greatly enriched the discussion by new and ingenious arguments for the removal of past antagonisms. We may add that, on its scientific side, the book abounds in clear and instructive statements of facts and laws that are now established, while the accompanying philosophical discussion brings them out in clearer light and more impressive aspects.

THE THEORY OF EVOLUTION OF LIVING THINGS, AND THE APPLICATION OF THE PRINCIPLES OF EVOLUTION TO RELIGION. Considered as Illustrative of the "Wisdom and Beneficence of the Almighty." By the Rev. GEORGE HENSLOW, F. L. S. Macmillan & Co.

WE noticed, last November, a book called the "Philosophy of Evolution," by B. Thompson Lowne, which we explained to be an Actonian Prize Essay. It was stated that Hannah Acton had left a lot of money to the Royal Institution, the income of which was to be spent as prizes for scientific essays, illustrating the wisdom and goodness of God. We stated that seven years ago the Solar Radiations were proposed for a prize, but that, no volume appearing to claim it, the money was left to accumulate, so that this year there were two prizes. But we were mistaken: the Solar Radiation man furnished his essay, and got his money. Nevertheless, such has been the good management of Widow Acton's funds, that there were two prizes this year; Lowne got one, and Henslow the other, for the book now before us. It is a volume of most excellent intentions, and not without some merit. It is, however, mainly significant from the evidence it affords that theologians are beginning to regard the situation calmly, and to adjust themselves to the new circumstances. Professor Henslow is not only a clergyman, but a man of science, a cultivated botanist, and son of the late eminent Professor of Botany in Cambridge. His opinions will, therefore, be entitled to weight from those of his own class. We published an interesting chapter from his book last month, under the title of "Genesis, Geology, and Evolution."

THE BIBLE AND THE DOCTRINE OF EVOLUTION. Being a Complete Synthesis of their Truth, and giving a sure Scientific Basis for the Doctrine of Scripture. By WILLIAM WOODS SMYTHE. 390 pages. London: H. K. Lewis.

WE have here another volume of the same scope as Prof. Henslow's, but a far abler book. The author's argument is close and searching, and the case he makes out is very strong. The point of view from which it is written is illustrated by the following passage from the Dean of Canterbury: "Possibly to our views of the nature of Christianity, and in our exegesis of Scripture, we have arrived only at partial truth; and do not distinguish with sufficient accuracy between what is certainly revealed and what is nothing more than a possible explanation of the divine word." The book exemplifies not only a thorough acquaintance with the doctrine of Evolution, and the extent and grounds of its proofs, but it exemplifies an equal mastery of biblical erudition. Nor is it offered as a mere ingenious attempt to ascertain the points of correspondence between Scripture statement and recent scientific speculations. The author is a profound believer in the principle of Evolution, which he maintains to be the fundamental law alike of Nature and Christianity, and he holds that "the plain and obvious interpretation of Scripture is the most congruous with the principles of Evolution." He recognizes his work as but the opening outline of an inquiry which must be carefully filled up, "the intention being to place stepping-stones, however unhewn, across a troublesome and heretofore impassable stream, which in the future may grow into a highway that the fool cannot err therein." The author acknowledges indebtedness for assistance and advice to a large number of clergymen whom he has consulted in the preparation of his work.

It is gratifying to observe that the author, who has thus far gone most thoroughly into the investigation he undertakes, shows also the most intelligent appreciation of the minds that have contributed to the working out of the great doctrine with which he is dealing. He says: "It does not seem to be sufficiently understood that Evolution owes much more to Mr. Spencer than to Mr. Darwin. The latter only de-

veloped part of the doctrine; never perceived its relation to the whole, nor its purely scientific interpretation. The works of the former are, therefore, most referred to here."

"The doctrine of Evolution, as developed by Mr. Herbert Spencer, is not an empty hypothesis excogitated as a plausible account of the phenomena of the universe, but a great philosophic system, founded solidly on carefully-corrected experience of the things and forces of the universe. And it becomes a subject of the deepest interest to compare the *priori* theory of the universe, contained in Scripture, with the *postoriori* doctrine formulated from the facts of our uniform experience."

We cordially recommend this volume to all who are interested in that aspect of the question to which it is devoted.

DESCRIPTIVE SOCIOLOGY. Part I. THE SOCIOLOGICAL HISTORY OF ENGLAND. By HERBERT SPENCER, assisted by James Collier. Price, $5. D. Appleton & Co.

IT has been repeatedly explained in the columns of the MONTHLY that Herbert Spencer has been engaged for some years in the formidable undertaking of collecting and classifying the data required of the scientific study of human society. For this purpose he divided the races of mankind into three great groups, or divisions: I. The Savage Races; II. The Extinct, or Decayed Civilizations; and III. The Existing Civilized Races. The part now published belongs to the third division, and in it Mr. Spencer applies his method to the Social History of England. If it be asked why he did not begin with Division I., presenting the simpler phenomena of uncultivated societies first, the reply is, that, while the publication of the whole series is by no means certain, and will be contingent upon the reception of the earlier parts, it was desirable to begin with a branch of the subject on which there cannot fail to be the most general interest, while it, moreover, subjects Mr. Spencer's method to the severest test. Besides, it is quite immaterial at what point the exposition is commenced, as it is perfectly simple and complete in each case.

The present work is free from all hypothesis and speculative views. Only the facts are given, and the authorities for the facts. Mr. Spencer expresses no opinion, and draws no inferences; he only classifies his materials in such a way that at one view we can take in all the great social facts of any epoch, and compare them with the phenomena that precede them, and out of which they grew, and those which follow them, and to which they give rise. In the "Principles of Sociology," upon which Mr. Spencer has now entered, he will work out the inductions and generalizations from this vast body of social facts in his own way; but, meantime, they have an independent value for all students who choose to draw their own conclusions.

The work is in a folio form, which was made necessary by the structure of the tables, the very first condition of which is, to bring into convenient comparison many series of facts. For all his statements made in the tables the authorities are given in a corresponding classification, the text consisting of quotations and extracts, which constitute the chief portion of the work. The material here published would form a large octavo volume of eight or nine hundred pages.

We consider this work one of very great public importance, as it is undoubtedly a large step forward in the direction of that knowledge which is more needed than any other. The question, What are the natural laws by which human societies have originated, been developed to their present state, and must still further advance?—the laws, therefore, by which their destiny is governed—is supreme at the present time. Our ideas upon the subject have hitherto been chaotic, and, for want of any fixed principle, the social field has been given over to quacks, dreamers, and swindlers of every quality. If science has any light to shed upon this matter that can help in the practical guidance of affairs, the world is in deplorable want of it. The work before us is only preliminary, but we think no candid mind can examine it without being convinced that it opens a new dispensation of social study, and paves the way to a more scientific consideration of social phenomena than we have ever before had. If in this it may be thought that we are writing under

a "bias," let us see what others say about it. The *British Quarterly Review* observes: "No words are needed to indicate the immense labor here bestowed, or the great sociological benefit which such a mass of tabulated matter, done under such competent direction, will confer. The work will constitute an epoch in the science of comparative sociology."

The able London correspondent of the *Tribune* says of the work: "The arrangement of the whole is so clear that the least scientific student in search of a fact will have no difficulty in putting his finger on what he wants. . . . The work is a gigantic one; its value, when complete, will be immeasurable; and its actual influence on the study of sociology, and help to that study, greater perhaps than any book yet published. It is a cyclopædia of Social Science, but a cyclopædia edited by the greatest of sociologists."

Mr. E. B. Tylor, author of "Primitive Culture," and one of the highest English authorities upon the study of the early development of society, writes, in *Nature* of October 30th: "So much information encumbered with so little rubbish, has never before been brought to bear on the development of English institutions. There is hardly a living student but will gain something by looking through the compilation which relates to his own special subject, whether this be law or morals, education or theology, the division of labor, or the rise of modern scientific ideas."

We can give no better general account of Spencer's work than to quote more fully from this review of it by Mr. Tylor:

"This first section is a methodical summary of the development of England, intellectual and moral, from the beginning of its history in Cæsar's time, to about A. D. 1850. At the first glance, it suggests a question which may disconcert not a few of the lecturers and tutors engaged in training students in history at our universities. This question is, whether the ethnological record of national life ought any longer to be treated as subordinate to the political record of the succession of rulers and the struggles for supremacy of ruling families, or whether the condition of society at its successive periods is for the future to be considered as the main subject, only marked out chronologically by reigns, battles, and treaties. This question has, it is true, been already raised. It is, in fact, the issue between historical chronicle and the philosophy of history as rival subjects of study. But Mr. Spencer's work brings it more clearly and practically into view than any previous one, as will be seen from the following outline of his scheme. It consists of two parts.

"The first part is a series of tables, arranged in thirty to thirty-five columns, each with a heading of some department of social life or history, which again are combined into groups. Thus the group of columns relating to the structure of society takes in political, ecclesiastical, and ceremonial departments, under which again we find separately given the laws of marriage and inheritance, the regulation of tribes and castes, the military and ecclesiastical organization, and the ceremonies and customs of daily life. Next, the group of columns devoted to the functions of society, regulative and operative, contains particulars of the morals, religion, and knowledge of each age, the state of language, and the details of industry, commerce, habitations, food, clothing, and artistic products. Three special columns at the beginning, middle, and end of this long colonnade, contain the skeleton of ordinary history: namely, the principal dates, names of rulers, and political events. Thus, by glancing across any one of the huge double pages, we see the whole condition of England at any selected period. Thus, in the century after the Norman Conquest, the influence of the invaders is observed in the growth of architecture, painting, music, poetry, the introduction of new food and more luxurious living, the importation of canonical law and of mathematics from the East, and so on through all the manifold elements which made up the life of noble and villain in our land. If the page be turned to the sixteenth century, the picture of English life is not less distinct. The scholastic philosophy is dying out, men's minds are newly set to work by the classical revival, by voyages into new regions, the growth of mercantile adventure and political speculation; chivalry ceases, archery declines; judicial torture is introduced, the 'Italian' crime of poisoning becomes fre-

quent; the ancient belief in witchcraft and pervading demons holds its ground, as do the miracle-plays and local festivals; but a highway act is passed, new roads are being made, the new houses have chimneys, their furniture and fare become more luxurious; the power of the old feudal families is destroyed, the Star-Chamber is new-modeled; church-fasts are still observed under pain of imprisonment, and high offices of state are still in the hands of churchmen, but among the signs of momentous change come the dissolution of monasteries, and the distinct appearance of a sect of Protestants. Thus the tabulated record goes on till it ends near the present day, among such items as Trades-Unions, Divorce Courts, the Manchester School, County Courts, Free Thought, Railways, Rifled Cannon, Pre-Raphaelitism, Chartism, Papal Aggression, and the crowding events of modern manufacture and science.

"It is by following the several columns downward, that the principle of Evolution, the real key to Mr. Spencer's scheme, is brought out into the broadest light. It seems most strange, however, that he should not have placed in its proper niche the evidence of prehistoric archæology. Mr. Spencer can hardly doubt that the stone implements found in England prove the existence of one, or probably two, stone-age populations before the Celts, who, under the name of Ancient Britons, begin his series. If he acknowledges this, why should a first link so important in his chain of evolution have been dropped? Otherwise the chain is carefully stretched out so as to display it from end to end. In many matters, simple and direct progress is the rule. From the ancient Briton's bow with its bronze-tipped arrows, to the cross-bow, the matchlock-gun, and thence through successive stages to the rifled breech-loader; from the rude arithmetic before the introduction of the 'Arabic' numerals, through the long series of importations and discoveries which led to the infinitesimal calculus in its highest modern development; from the early English astronomy, where there was still a solid firmament studded with stars, and revolving on the poles about the central earth, to the period when the perturbations of planets are calculated on the theory of gravitation, and the constitution of the fixed stars examined by the spectroscope—these are among the multitude of cases illustrating the development of culture in its straightforward course. Harder problems come before us, where we see some institution arise, flourish, and decline within a limited period, as though resulting from a temporary combination of social forces, or answering only a temporary purpose in civilization.

"To take an instance from Mr. Spencer's table, English history has seen the judicial duel brought in at the Conquest, flourishing for centuries, declining for centuries more, till its last formal relic was abolished in 1820. Again, in the Old English period, marriage appears as a purely civil contract, on the basis of purchase of the wife; then with Christianity comes in the religious sanction, which by 1076 had become so absolute that secular marriages were prohibited: with a strong turn of the tide of public opinion, the English Marriage Act of 1653 treated marriage as a civil contract, to be solemnized before a justice of the peace; till, after a series of actions and reactions, in our own day the civil and ecclesiastical solemnization stand on an equal footing before the law. Closely similar has been the course of English society on the larger question of a National Church, which, soon after the introduction of Christianity, claimed an all but absolute conformity throughout the nation, practically maintained the claim for ages, and then was forced back to toleration, which has at last left it with a supremacy little more than nominal. This is not the place to discuss these subjects for themselves, but to show how the table before us, by its mere statement of classified events in chronological order, must force even the unwilling student to recognize processes of evolution in every department of social life. The writer of the present notice once asked an eminent English historian, a scholar to whom the records of mediæval politics are as familiar as our daily newspaper is to us, whether he believed in the existence of what is called the philosophy of history. The historian avowed his profound distrust of, and almost disbelief in, any such philosophy. Now, it may seem a simple matter to have tabulated the main phenomena of English social and political

history in parallel columns, as Mr. Collier has here done under Mr. Spencer's direction, but his tables are a sufficient answer to all disbelievers in the possibility of a science of history. Where the chronicle of individual lives often perplexes and mystifies the scholar, the generalization of social principles from the chronicler's materials shows an order of human affairs where cause and effect take their inevitable course, as in Physics or Biology."

MISCELLANY.

New Material for Dental Plates.—Among the novelties exhibited at the American Institute Fair is a new base for artificial teeth, the invention of a New York dentist. It consists mainly of fish-scales, which, dissolved and combined with certain fibrous and adhesive substances, form a compound that is said to be well adapted for use as dental plates. Greater strength, durability, and lightness, and freedom from all taste, are the advantages claimed for it over the materials in common use. It is capable of receiving a fine polish, and may also be readily colored to any desired tint, qualities which adapt it to a great variety of purposes outside of dentistry. It is also said to be an excellent material for waterproofing cloth.

Meteorological.—In his report for 1872, Mr. Daniel Draper, Director of the Meteorological Observatory in Central Park, considers the following points:

1. "Has the summer temperature of the Atlantic States undergone any modifications?

2. "What is the direction in which atmospheric fluctuations cross the United States?

3. "Is it possible to trace the passage of American storms across the Atlantic, and predict the time of their arrival on the European coast?"

By carefully-arranged tables, he shows that no change has taken place in summer temperature, and concludes that "the mean heat of summer and the mean cold of winter are the same now as they were more than a century ago."

These conclusions are from observations made in Boston, New Haven, New York, Philadelphia, and Charleston. It may be added that, in his former reports, it was shown that over the same areas the annual rainfall has neither increased nor diminished.

The movement of atmospheric fluctuations is illustrated by diagrams founded on observations at the Observatory, and the daily maps published at Washington. It appears that these movements are not all cyclonic—many are like waves of the ocean, long and straight, and have a forward motion. This motion over the United States is eastward. The velocity of this motion has been determined in a great number of instances for the years 1869, 1870, 1871, and 1872. During the last year the highest forward velocity was 569 miles in twenty-four hours; the lowest velocity, 82 miles in twenty-four hours. The highest velocity recorded was about 29 miles an hour, or 690 miles in twenty-four hours; this occurred on the 28th of March, 1870. The time required to cross the Atlantic varied from ten to twenty days. It sometimes happens that storms which leave our coast three and four days apart arrive on the coast of Europe together, and, in such cases, the storm is usually severe. The observations made show that, out of eighty-six storms expected to cross the Atlantic, only three seem to have failed. Moreover, it is shown that the direction of the movement is maintained, so that it may be known several days in advance what part of the coast of Europe will be covered by the advancing storm.

The great practical value of these observations and reports will be at once recognized, and the conclusions they suggest and confirm are among the most interesting of the results of modern scientific research.

Sewage Fertilization.—The following, from the report of the committee of the British Association on the "Purification and Utilization of Sewage," effectually disposes of some of the more important objections that have been urged against the use of sewage for fertilizing purposes:

"By properly-conducted sewage irrigation a solution is afforded to the question of sewage utilization. It has already been stated that a precipitation process, or some clarifying process, may be found useful: in

all instances it is essential that the land should be well underdrained, and that the sewage should all pass through the soil, and not merely over it; otherwise, as has been shown, it will only occasionally be satisfactorily purified. The catch-water, or, as the committee has termed it, the "supersaturation" principle, is not defensible either on agricultural, chemical, or sanitary principles. An irrigation farm should therefore carry out intermittent downward filtration on a large scale, so that the sewage may be always thoroughly purified, while at the same time the maximum of utilization is obtained.

"It is certain that all kinds of crops may be grown with sewage, so that the farmer can grow such as he can best sell. Nevertheless, the staple crops must be cattle-food, with occasional crops of corn; and it is also certain, from the analysis of the soil, that it has become very much richer, and that the manurial constituents of the sewage accumulate in it. Cattle should be fed on the farm, which leads to a vast increase in the production of meat and milk, the great desiderata of the population producing the sewage. Thus the system of farming must be specialized and capital concentrated, the absence of which conditions has proved a great barrier to the satisfactory practical solution of the sewage question.

"The committee has not been able to trace any ill effects to the health of the persons living around sewage farms, even when badly conducted; nor is there any proof whatever that vegetables grown thereon are in any way inferior to those grown with other manure. On the contrary, there is plenty of evidence that such vegetables are perfectly suited for the food of man and beast, and that the milk given by cows fed on sewaged grass is perfectly wholesome; thus Mr. Dyke, Medical Officer of Health of Merthyr Tydfil, states that, since the abundant supply of milk from the cows fed on irrigated grass, the children's mortality has decreased from 48, 50, and 52 per cent. of the total deaths, to only 39 per cent., and that so far from diarrhœa having been made more prevalent by the use of sewaged cabbages, 'last year the Registrar-General called attention to the fact that diarrhœa was less prevalent in Merthyr than in any place in England and Wales;' and he expressed his belief in 'the perfect salubrity of the vegetable food so grown.'

"With regard to the assumption which has been made that entozoic diseases would be propagated by irrigation, all the evidence that the country has been able to collect, and more especially the positive facts obtained by experiments, are against such an idea; and the committee is of opinion that such disease will certainly not be more readily propagated by sewage irrigation than by the use of human refuse as manure in any other way, and probably less if the precaution be taken of not allowing the animals to graze, but always having the grass cut and carried to them."

Length of Thread of the Silk-worm.—Prof. Riley, of St. Louis, informs us that the calculation, on page 663 of the last volume, as to length of thread and weight of cocoon spun by the mulberry silk-worm, is altogether exaggerated. Instead of the thread being 11 miles in length, it averages not much more than half a mile, and seldom exceeds 1,000 yards; while a single mile, instead of 28 miles of it, would weigh about 15½ grains.

The Constitution of Carboniferous Strata.—At a general meeting of the British Association, Prof. W. C. Williamson delivered an interesting discourse on "Coal and Coal Plants." The speaker said that most men are now agreed as to the vegetable origin of coal, and the drift theory of its accumulation. It was once a vegetable soil, which accumulated under the shade of primeval forests, growing on areas of depression. In time the land sank beneath the sea, and the vegetable elements were buried under layers of sand and mud, accumulations of which again restored the area to the sea-level, when spores of plants once more germinated in a blue mud, and the succession of phenomena which had previously occurred was again renewed. The frequent repetition of these changes, finally, resulted in the accumulation of the thousands of feet composing the vertical series of rocks which are termed the carboniferous strata. Attention had been called by Prof. Huxley to some

minute coin-like bodies which are very abundant in some coals, and which had been previously noticed by Witham, Dawson, and others. The larger of these bodies Huxley regarded as spore-cases, and the smaller as spores, while he considered that their disintegration had led in most cases to the formation of the bulk of what we call coal.

Prof. Williamson showed in detail that these were not spore-cases, but two kinds of spores—microspores and macrospores—such as severally occur in the upper and lower portions of the fruits of many living club-mosses. Their sizes and structure demonstrate the truth of this conclusion, which is further sustained by the fact that spore-cases are not deciduous, but spores are; and these objects, having fallen in such vast myriads from gigantic club-mosses, can only have been deciduous organs. The lecturer then gave reasons for concluding that these spores had played a much more limited part in the origin of coal than Huxley had assigned to them. According to Huxley, coal is composed of mineral charcoal and coal proper—the latter term being equivalent to spores altered or unaltered. Prof. Williamson, on the other hand, recognized three such elements: mineral charcoal, that is, fragments of fossil wood retaining its structure; coal proper, that is, mineral charcoal disorganized; and spores in various states.

We now distinguish in coal three groups of fossil plants: 1. Those of which we have the form but not the organization: 2. Those of which we have both form and organization; 3. Those of which we know the structure, but are ignorant of the outward form. What has yet to be done is the correlation of the first and last of these three groups. Brogniart long ago showed that most of the coal-plants were cryptogamic—chiefly calamites (allied to living horse-tails); lepidodendra (represented by the club-mosses); ferns, and plants supposed to represent pines and firs of the group known as gymnospermous exogens.

Leached Ashes as a Fertilizer.—In a report to the Connecticut State Board of Agriculture, Prof. S. W. Johnson gives the results of some analyses made by himself of specimens of leached ashes used for fertilizing purposes. By these analyses leached ashes are found to contain: less than one per cent. of *potash;* a large proportion of *water* (not less than 35 per cent.); considerable *sand* or *soil*, and *unburned coal*, amounting to from 6 to 15 per cent., when not intentionally or largely adulterated; about 45 per cent. *carbonate of lime*, which is the chief fertilizing element in leached ashes; a little more than 1 per cent. of *phosphoric acid*, and 3 to 4 per cent. of *magnesia*. They contain no *nitrates*, but the carbonate of lime in them favors the development of nitrates when they are incorporated with the soil, especially in conjunction with animal manures.

Prof. Johnson states that the price of this material is 35 cents per 100 lbs., or $7.00 per ton. Its fertilizing value lies exclusively in the 20 or 30 lbs. of lime, 3½ of magnesia, 1½ of phosphoric acid, and 1 or 2 lbs. of potash in each 100 lbs. But these materials may be procured in other forms, as follows: 35 lbs. of fresh-burned oyster-shell, or stone-lime, will furnish the lime; 15 lbs. of any good superphosphate will supply the phosphoric acid; the magnesia and potash together may be obtained in 40 lbs. of German potash salts, and there will then be 4 or 5 lbs. of potash and 6 lbs. of sulphuric acid extra.

If the lime be slaked with water in which the superphosphate and potash salts have been soaked and partially dissolved, the resulting mass will contain not only all the fertilizing elements of 100 lbs. of leached ashes and more, but these elements will be in such a state of fine division as to render the mixture in all respects equal to the ashes themselves.

From these data any one can readily calculate the cost in his own locality of a substitute for leached ashes. "It must not be forgotten," adds Prof. Johnson, "that a mixture made of fresh-burned lime should be allowed to become mild by exposure to the air, or its peculiar effects on the soil should be anticipated and provided for."

Age of Metamorphic Rocks.—"The Metamorphism of Rocks" is the title of a paper read at the Association meeting, by Prof. T. Sterry Hunt. The author briefly noticed the changes produced in rocks by

the action of water, air, and various gases. While some geologists had supposed that many of these, such as gneiss, greenstone, serpentine, talcose, and chloritic rocks, were igneous products, more or less modified by subsequent chemical action, others maintained that they were the result of aqueous sedimentation, and subsequently crystallized. This was the teaching of Hutton; and when early in the present century the crystalline rocks of the Alps were shown to rest on uncrystalline fossiliferous strata, it was suggested that the overlying crystalline strata were newer rocks which had undergone a metamorphism, to which those just beneath had not been subjected. This view spread until the great crystalline centre of the Alps was considered to be in part of secondary and even of tertiary age.

The author detailed the course of study by which he was led to question this view, and showed that there is no evidence in the Alps to support it; that Sedgwick and Nicoll had discredited the palæozoic age of the crystalline schists regarded by Murchison as Cambrian and Silurian; and, finally, gave the observations by which he had satisfied himself that the crystalline rocks of the Green and White Mountains, and their representatives in Quebec, New Brunswick, and on the Blue Ridge, were more ancient than the oldest Cambrian or primordial fossiliferous strata.

Tests for Glycerine.—The so-called pure glycerine of commerce, according to the *Journal of Applied Chemistry*, is often contaminated with metallic chlorides. Traces of ammonia are also sometimes present; and it not unfrequently contains oxalic acid or soda. The first-named impurity may be detected by diluting the glycerine with twice its volume of water and adding nitrate of silver. If the glycerine only becomes opalescent, the quantity of chlorides is not great enough to be injurious, but, if a flaky precipitate is produced, it indicates that the glycerine is unfit for medicinal use. To detect ammonia, mix the glycerine with its own volume of caustic potash, and bring a glass rod previously dipped in dilute muriatic acid over the mixture. If ammonia is present in injurious quantity, whitish vapors of chloride of ammonium will be formed. Oxalic acid may be detected, by adding lime-water, acetate of lime, or a mixture of chloride of calcium and acetate of soda. If the glycerine becomes turbid within five minutes after the reagent is added, it should be rejected. Traces of soda can only be revealed by evaporating the glycerine to dryness, and testing the residue.

American Origin of the Garden Raspberry. — Although the garden raspberry (*Rubus Idæus*) was imported from Europe, yet Dr. Asa Gray has lately made known some facts that would seem to make it certain that this plant, which is not indigenous to Europe, is a native of Japan and North America. Wild specimens from British America and the Rocky Mountains, it seems, must be referred by the botanist to the cultivated species, *Rubus Idæus*. Prof. Areschoug, who has devoted special study to the *Rubi* of Europe, concludes that this species did not originally have its home in Europe, but that its origin is to be found in the east of Asia, namely, Japan and the adjacent countries, and perhaps in North America. He also thinks that "the Asiatic and North American floras have reciprocally mixed with each other by passing Behring Straits and the islands which in its neighborhood form a bridge between the two continents."

Rapidity of Vegetable Growth.—A writer in the *Gardener's Chronicle* gives some illustrations of the prodigious activity manifested in the growth of plants during a few weeks. The process of growth, being gradual and noiseless, and moreover of everyday occurrence, is generally disregarded. And yet, what a quantity of water must be absorbed and exhaled, how much air inhaled and exhaled, how much carbon fixed during the process! The writer gives some measurements of an ordinary plant, the *Abies nordmanniana*, a species of silver-fir, which will give a good idea of the rapidity of growth.

The shrub was only two feet six inches in height, and the number of young shoots of this year's growth on it 585. These shoots vary in length from half an inch to six inches, and their aggregate length is 1,171 inches, or nearly 98 feet. Dividing the aggregate of the shoots (1,171 inches)

by their number (585), we find the mean length of the shoots to be about two inches. The average number of leaves on each inch of a number of shoots, taken at random, was 34, so that the total number of leaves on these 585 shoots may be set down at 39,814. Assuming each leaf to be only one inch in length—which is considerably under the mark, even when all the small, undeveloped leaves are taken into consideration—we should have for the leaves a length of about 3,501 feet, so that, in round numbers, we may say that, including the shoots and leaves, the growth in length alone of this very moderate-sized young tree, during this season, has amounted to the prodigious number of 3,600 feet; and, if the shoots and the leaves could all be placed end to end in a continuous line, they would extend considerably more than half a mile.

Action of the Sand-blast.—At a recent meeting of the British Microscopical Society, Mr. Wenham exhibited a piece of glass "ground" by the sand-blast process, which, under the microscope, presented a very different appearance from common ground glass. It is found that the glass or other material, worn away by the sand-blast, is not ground away at all, but broken up by a battering action, similar to that of leaden bullets against a block of granite. Hence it is that, although, by the usual grinding process, ordinary sea-sand can make no impression on corundum, a blast with a pressure of 300 pounds to the square inch will perforate it in a short time. Nay, even the diamond itself may thus be speedily worn away.

A polished glass surface, exposed for an instant to the sand-blast, shows an aggregation of points of impact, from which scales of fractured glass have broken away in an irregular radial direction. It appears as if a pellet of glass had been driven in by the collision of the sand, and the wedge-like action thus set up had driven away the surrounding glass. All these spots, or indentations, when tested by the polariscope, show a colored halo round each, proving that the glass surface is under strain and ready to yield to further fracture. The action, therefore, is not so much due to the hardness of the striking particles as to the force and velocity of impact. This is sufficiently great to destroy the cohesion of the material operated upon. The external layer is carried against the under stratum, and the material is crushed and disintegrated by a portion of its own body.

NOTES.

Dr. Charles P. Russell gives a tabulated statement of the mortality of the various States of the Union, from which we borrow the following regarding the death-rates of various cities: The highest death-rate in 1872 was exhibited by Memphis, where the deaths were 46.6 in each 1,000 inhabitants. Other cities followed in this order: Savannah, 39.2; Vicksburg, 36.5; Troy, 34; Hoboken, 32.9; New York, 32.7; Newark, 31.6; New Orleans, 30.6; Boston, 30.5. The rate for Philadelphia was only 26.1; Brooklyn, 28.1; St. Louis, 20.1; Chicago, 27.6; Baltimore, 25.1; Cincinnati, 20.5; San Francisco, 17.2. This compares not unfavorably with the mortuary statistics of British cities, where the lowest rate was 21.4; that of London, Bombay, and Calcutta, show only 29.2 and 25, respectively. The highest known death-rate prevailed in Valparaiso, Chili, 66.9.

Inoculating the vine with pure essence of *Eucalyptus globulus* is said to be an effectual remedy for the phylloxera or grape-vine disease. The mode of applying the remedy is this: a broad incision is made through the bark at the neck of the vine, in which a few drops of the essence are deposited by means of a small camel's-hair brush. In about three days the phylloxera insect entirely disappears, while the vine is not in the least injured by the operation.

The practice of ringing and tolling bells by swinging the clapper or tongue violently against the side of the bell while the latter is stationary, is said to be a very frequent cause of fracture. The bell itself should always be in motion when struck by the object that is intended to set it vibrating.

Pine-leaves, says the *Mining and Scientific Press*, are largely utilized in Europe. They are converted into a kind of wool or wadding, which is used for upholstery instead of hair. A kind of flannel is also made from this fibre, which is said to be very superior for many hygienic uses, as for rheumatism and skin-diseases. Vests, drawers, loose shirts, etc., are also made of this material. In the process of manufacture an ethereal oil is obtained, very useful as a solvent, and as a curative agent. Gas is made from the refuse, and used for lighting the manufactories; or the entire refuse may be

pressed into the form of bricks, when it becomes an excellent fuel.

THE material used for capping champagne, beer, and mineral-water bottles, supposed to be simply tin-foil, turns out on examination to consist almost entirely of lead. Dr. Wittstein, after analyzing a great many of these capsules, states that the proportion of tin in their composition varies from one to ten per cent., all the rest being lead; and that the prevalent habit of closing the top of the bottle with the cap after the cork has once been drawn is a dangerous one, as the acid contents of the bottles even in minute quantities, in contact with the cap at the mouth of the bottle will rapidly dissolve the lead, and thus give rise to a poisonous solution.

ONE of the most distressing, because rarely remedial forms of chronic mania, says the London *Lancet*, is that produced by the mental shock of fire. The patient wears a peculiar aspect, in which suspicion is one element, and a settled look of panic another. Photographs of such inmates of asylums are remarkably uniform in their representation of this expression. The great fire at Chicago has produced a large number of lunatics, no fewer than 250 sufferers from it having been adjudged insane by the courts of Illinois. Considering the privations, however, to which the houseless victims of that conflagration were in many cases exposed, other causes than fire-panic may be credited with a share of the result.

ACCORDING to Van Beneden, as quoted in the *American Naturalist*, an excellent method of preparing for preservation and study such jelly-like and perishable organisms as medusæ, ctenophora, noctilucæ, etc., is to immerse them for from fifteen to twenty-five minutes, when fresh, in a weak solution of osmic acid, when, after washing several times in water, they may be kept, for weeks or months without impairment, in alcohol. The acid colors a portion of the tissues brown, but this rather facilitates than hinders study, as it brings into view certain structures that are otherwise less clearly visible. The agent also hardens the substance of the animal, so that it may be handled without danger of disorganization, and readily cut into sections if desired.

FEVER is the most prolific cause of death in India, and, in ordinary years, carries off many more victims than all other diseases together. The returns, exclusive of Bengal and the northwest provinces and Burmah, give upward of 900,000 deaths from fever in 1871, and the total number in all India cannot be far short of 1,500,000. At least half of these lives might be saved by putting quinine in every native druggist's shop at one rupee per ounce.

THE United States Light-house Board have under charge 179 sea and lake coast lights, 394 river and harbor lights, 22 light-ships, and 33 fog-signals, that are operated by steam or hot-air engines.

THE *Gazette des Campagnes* recommends dipping the end of plant-slips in collodion before setting them out. The collodion should contain twice as much cotton as the ordinary material used in photography. Let the first coat dry, and then dip again. After planting the slip, the development of the roots will take place very promptly. The method is said to be particularly efficacious with woody slips, geraniums, fuchsias, and similar plants.

CHLORIDE of cobalt, sometimes used as the basis of a sympathetic ink, is, according to Siegen, a powerful poison. A grain killed a frog in half an hour. Four and a half grains killed a strong rabbit in three hours. The poison acts directly upon the muscles of the heart. Nitrate of cobalt is equally poisonous, and acts in a similar way.

CAMPHOR-WOOD promises to become, at no distant day, an important article of commerce. It grows freely in tropical countries, without cultivation. The tree attains large proportions, being sometimes found fifteen feet and upward in diameter, and of proportionate height. It is very valuable for carpenter's work, being light, durable, and not liable to injury from insects. Its aromatic perfume is well known. The wood is strong and very durable, and is especially serviceable in ship-building. Camphor-wood piles have been known to remain in a good state of preservation over a hundred years.

IXTLE-FIBRE, which grows abundantly on the southern shores of the Gulf of Mexico, is remarkable for its lustre, strength, and flexibility. Within the thin envelope which forms the leaf, there is a perfect skein of thread of extraordinary tenacity, length, and fineness. The outer covering can be easily removed by a chemical process, and the whole fibre made available without further expense. The plant, it is said, can be brought to New York for less than fifty dollars per ton.

IN a French industrial establishment, employing 630 men, chiefly vegetarians, the sick fund was constantly in debt. The director of the establishment took measures for the introduction of butcher's meat into the food of the men, and the effect was such that the average loss of time per man, on account of illness or fatigue, was reduced from fifteen to three days per annum. Thus the animal food saved twelve days' work a year per man.